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INTEL® CORE i7-6700K

14 NANOMETERS HAVE NEVER BEEN BIGGER P. 12



ASUS Z170 MOTHERBOARDS

UNLEASH THE 6TH GEN CORE.
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A detailed view of the ASUS Maximus VIII Hero motherboard, showing its blue PCB, silver heatsinks, and various components. The motherboard is angled, highlighting its design and the 'MAXIMUS VIII HERO' branding on the heatsinks.

MAXIMUS VIII HERO

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Mad Reader Mod



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CPU Goes To QuakeCon

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Monthly last-page interview with people who help to shape the PC industry.

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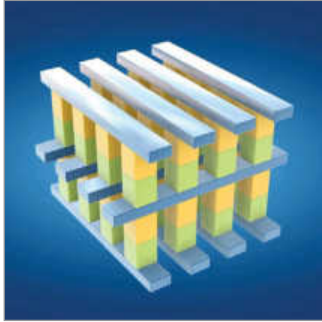
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Intel & Micron Create New Memory That's 1,000x Faster Than NAND

Power users and technology enthusiasts rejoiced recently when Intel and Micron announced they had already started production on a new type of non-volatile memory called 3D Xpoint. The companies note the memory is a “major breakthrough,” represents the “first new memory category in more than 25 years,” and is up to 1,000 times faster than the NAND memory now found in SSDs and other flash-based devices. 3D Xpoint memory is much denser, the companies report, in that memory cells are built using new materials and it uses a “cross point architecture” that does not involve traditional transistors. The companies say the architecture of the cells resembles a three-dimensional checkerboard, with memory cells at the intersections that can be individually addressed, allowing for faster reads and writes of small chunks of data. Wafers of the memory are now in production, and the technology should lead to new products.

GIGABYTE Announces Two GeForce GTX 950 Overclock Edition Cards

GIGABYTE has announced two new Overclock Edition graphics cards. Both cards use NVIDIA's GeForce GTX 950, which is a variation of the GM206 GPU. The GV-N950WF2OC-2GD is overclocked to 1,102MHz (base) and 1,279MHz (boost). The standard version of the graphics processor has a base clock of 1,026MHz and boost of 1,190MHz. The card has 2GB of GDDR5 and comes with GIGABYTE's WINDFORCE 2X cooler, which has two of GIGABYTE's fans with the special blade design that increases airflow. The second new card is the GV950OC-2GD, which comes with a slightly lower overclock of 1,064MHz (base) and 1,241MHz (boost). This card has a one-fan cooler and is meant to be used in smaller builds such as mini-ITX systems. Both cards come with GIGABYTE's OC GURU II overclocking software.



WATCHING THE CHIPS FALL

Here is the pricing information for various AMD and Intel CPUs.

CPU	Released	Original Price	Last Month's Price	Online Retail Price*
AMD FX-9590 Eight-Core	6/11/2013	N/A	\$229.99	\$229.99
AMD FX-9370 Eight-Core	6/11/2013	\$375	\$229.99	\$209.99
AMD FX-8350 Eight-Core	10/23/2012	\$195	\$174.99	\$169.99
AMD FX-8320 Eight-Core	10/23/2012	\$169	\$144.99	\$144.99
AMD FX-6350 Six-Core	4/30/2013	\$132	\$125.99	\$129.49
AMD A10-7850K Quad-Core	1/14/2014	\$173	\$129.99	\$129.99
AMD A10-7800 Quad-Core	7/2/2014	\$153	\$124.99	\$124.99
AMD A10-7700K Quad-Core	1/14/2014	\$152	\$119.99	\$121.99
AMD A10-6800K Quad-Core	6/4/2013	\$142**	\$139.95	\$143.89
AMD A10-5800K Quad-Core	10/2/2012	\$122**	\$89.99	\$89.99
Intel Core i7- 5960X Eight-Core	8/29/2014	\$999**	\$1,049.99	\$1,049.99
Intel Core i7- 4960X Six-Core	9/3/2013	\$990**	\$1,029.99	\$1,029.99
Intel Core i7- 5930K Six-Core	8/29/2014	\$583**	\$579.99	\$579.99
Intel Core i7- 4930K Six-Core	9/3/2013	\$583**	\$618.16	\$616.99
Intel Core i7- 5820K Six-Core	8/29/2014	\$389**	\$389.99	\$389.99
Intel Core i7-6700K Quad-Core (Skylake)	8/5/2015	\$359**	(New)	\$359.99
Intel Core i7-4790K Quad-Core	6/25/2014	\$339**	\$339.99	\$339.99
Intel Core i7-4820K Quad-Core	9/3/2013	\$323**	\$327.99	\$329.99
Intel Core i7-4790 Quad-Core	5/11/2014	\$303**	\$309.99	\$309.99
Intel Core i5-6600K Quad-Core (Skylake)	8/5/2015	\$249**	(New)	\$249.99

* As of August 2015

** Manufacturer's estimated price per 1,000

ASRock Z170 OC Formula Officially Launches & Grabs 3 World Records

ASRock finally launched its Z170 OC Formula motherboard, announcing at the same time that it has been used to claim three more world records by overclockers SPLAVE.ROM and Jon Lamm. The new Z170 OC Formula supports dual-channel DDR4 to 4133+(OC), 4-way Crossfire, and quad-SLI. It has 4 x PCIe 3.0 x16, 1 x PCIe 3.0 x1, 1 x PCIe 2.0 x1, and one vertical half-sized mini-PCIe slots. There are three SATA Express, 10 SATA 3, and three Ultra M.2 (PCIe Gen3 x4 and SATA 3) ports. MSRP for the ASRock Z170 OC Formula is \$180.



Corsair Announces STRAFE RGB & STRAFE RGB Silent Keyboards

The STRAFE RGB Silent is the first keyboard to include Cherry MX Silent mechanical keys, which have a patented noise-reduction technology. The plank is fully programmable so you can assign macros to any key, plus the backlighting can be customized. MSRP is \$159.99. If going silent isn't your thing, Corsair's other new keyboard, the STRAFE RGB, may be more to your liking. It has similar features but comes with your choice of Cherry MX "Red" or "Brown" switches. The STRAFE RGB has an MSRP of \$149.99. Both keyboards should be available in October.



PowerColor Devil R9 390X: The First Hybrid Cooling R9 390X

TUL says the PowerColor Devil R9 390X is the only AMD Radeon R9 390X on the market to use hybrid cooling. The hybrid cooling system provides the best of two worlds: a solid environment for extreme OC capabilities and stability, and a Smart Air Cooling system that detects the MOSFET's temperature automatically and controls fan speed. A 15-degree upheaved fan top cover design ensures the best airflow from the MOSFET to bracket for more efficient cooling while also reducing power consumption and prolonging fan longevity. No official word yet on price.



ADATA's Premier SP550 SSDs Aim At Price/Performance Sweet Spot

ADATA has announced a new line of SSDs called Premier SP550. The new line uses TLC (triple-level cell) NAND, a type of flash memory that is generally less expensive but also slower than other types of NAND, to hold down costs. To help improve speeds, ADATA has used the latest SMI controller and added support for SLC caching and DDR3 DRAM cache buffer. ADATA says the Premier SP550 is aiming at a performance sweet spot, and the SSDs have read/write speeds of 560/410 MBps. The new line is available in these capacities: 120GB, 240GB, 480GB, and 960GB.



BenQ Introduces XR3501 Curved Display For Immersive Gaming

The new BenQ XR3501 LCD monitor is big, with a huge 35-inch screen. It's fast, with a speedy 144Hz refresh rate. And then it goes one step further: This display features the greatest curvature currently available in an LCD monitor. BenQ says it wanted the XR3501 to envelop the gamer and provide a truly immersive entertainment experience, so it gave the screen a 2000R curvature, which is similar to that found on an IMAX theater screen. The XR3501 also has a 21:9 aspect ratio and sports 2,560 x 1,080 resolution. This screen will put you right in the middle of the action. MSRP for the XR3501 is \$999.



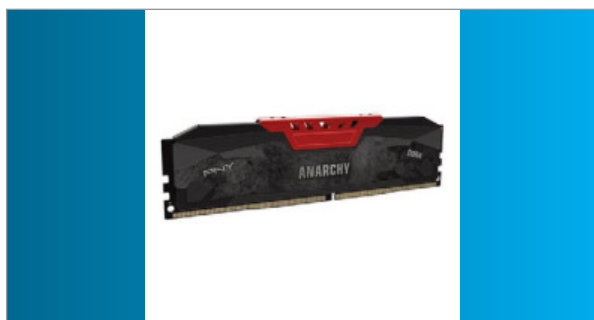
NZXT GRID+ V2 Controller Makes It Easy To Control Up To Six Fans

A modern interface and streamlined installation help make the NZXT GRID+ V2 simple and unintrusive: two great qualities for a digital fan control. The fan controller has six individually controlled channels and up to 30 watts total output. Two fan control profiles—silence and performance—adjust fan speeds based on CPU temperature. Or, you can use the included software to create multiple custom fan profiles and manually adjust fan speeds to suit your own needs. The \$29.99 GRID+ V2 doesn't require an open 5.25-inch slot, so you can install it virtually anywhere.



PNY's New Anarchy DDR4 Desktop Memory Kits Are Ready For OC'ing

PNY designed its new Anarchy X DDR4 2800MHz and Anarchy DDR4 2400MHz for extreme overclocking. The company says both upgrades combine tightly screened components and select ICs to offer the best in speed, low latency, stability, and overclocking that gamers and PC enthusiasts need. Uniquely designed heat spreaders are sleek and stylish and come with clips in a variety of colors. The Anarchy DDR4 2400MHz kits come in 4GB to 16GB capacities at prices ranging from \$39.99 to \$134.99. The Anarchy X DDR4 2800MHz is a 16GB kit for \$149.99.



EK Announces AIO Liquid Cooling Products With Predator Line

EK Water Blocks plans to roll out its first all-in-one cooling products this fall. The company says its new EK-Predator product line will have two models, a 240mm version and a 360mm version, and will target the mainstream market. The company cobbled together individual components aimed at enthusiasts and modders from its existing product lines and assembled them into the new AIOs. Those components include Supremacy MX water blocks (designed for Intel CPUs), CoolStream PE radiators, Vardar fans, a 6W DDC pump, and an integrated Fan Splitter hub.



Microsoft Bounty Programs To Be A Lot More Bountiful

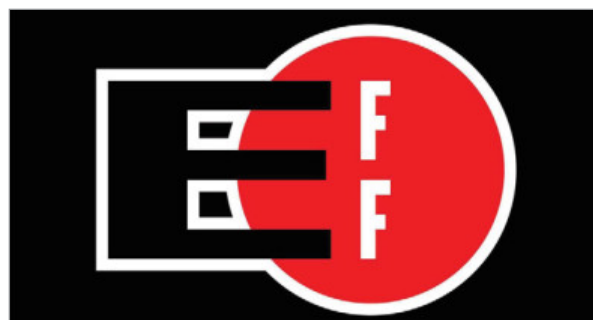
Microsoft is expanding its Bounty Programs in an effort to bring “defense up on par with offense,” the company states.

With the rollout, the Bounty For Defense is increasing from \$50,000 to \$100,000 USD, which, Microsoft notes, “rewards the novel defender equally for their research.” Also, Microsoft is running a bonus period until Oct. 5 of this year for any authentication vulnerabilities in MSA (Microsoft Account) and AAD (Azure Active Directory). Between now and Oct. 5, payouts will double to \$30,000 USD.



Browser Extension Works To Block “Sneakiest Kinds Of Online Tracking”

The Electronic Frontier Foundation is working to help keep more of your Web browsing habits private. The EFF’s Privacy Badger 1.0 browser extension blocks certain kinds of super-cookies and browser fingerprinting, which are two relatively new techniques the online tracking industry uses to follow Internet users from site to site. Privacy Badger works with the new DNT (Do Not Track) policy, which you can set in your browser settings or by installing Privacy Badger to opt out of online tracking (Privacy Badger will not block third-party services that honor all DNT requests).



Take Beautiful Photos Through That Rain-Covered Window

If you’ve taken a picture through some sort of obstruction and haven’t been happy with the results, a group of researchers from MIT and Google feel your pain. The researchers detail their plan in “A Computational Approach for Obstruction-Free Photography.” Rather than capturing a single image, users take a short image sequence while slightly moving the camera, similar to taking a panoramic shot. An algorithm uses the differences that often exist in the relative position of the background and the obstructing elements from the camera and separates them based on their motions. See below for a before and after shot.



Parallels Desktop For Mac Supports Windows 10, Adds New Features

Parallels has been making tools to help Mac users run Windows applications for years, and it’s continuing the tradition for Windows 10. Parallels Desktop 11 for Mac is up to 50% faster than previous versions, is ready for OS X El Capitan, and has a Travel Mode that temporarily shuts off resources that drain power, extending battery life up to 25% when you’re on the go. Desktop 11 lets Windows 10 users take advantage of Cortana when using both Windows and OS X, marking the first time Parallels Desktop has ever made a Windows feature available for OS X applications.



Should You Go Solar? Google Knows.

Interested in investing in solar power but not sure it'll work in your home or neighborhood? Google introduced a new tool, Project Sunroof, that can help you decide. It's simple: Enter your address and let Project Sunroof go to work. By combining the aerial mapping used by Google Earth with information from other databases, Project Sunroof figures out how much sunlight hits your roof throughout the year, says Carl Elkin, who developed the idea as part of his recent 20% time for Google. The high-resolution mapping accounts for roof orientation, shade from trees and buildings, and local weather. The tool is in pilot phase, available only for addresses in Boston, Fresno, and the San Francisco Bay Area, but should be more widely available soon.



Now, Direct From Outer Space: More Affordable Internet Service

About two-thirds of the world still does not have access to the Internet. That's one reason Farooq Khan, president of Samsung Research America, cites for developing a vision of a "Space Internet" to provide Internet access to virtually every part of the globe. Khan's proposal is to deploy thousands of low-cost micro-satellites placed in low-Earth orbit. Combined with a new wireless architecture, each satellite could provide terabit-per-second data rates, Khan says. Together, the satellites could provide Zetabyte/month capacity, which equates to about 200GB per month for 5 billion users worldwide.



Most Teens Finding Friends Online

For teens, spending time online is about more than just playing games, posting to Facebook, and sharing photos on Instagram—it's about making friends. According to a study by Pew Research Center, 57% of teens between ages 13 and 17 have made a new friend online, and 29% have made more than five new friends online. Social media sites are the most common spots for meeting friends online, followed by video games. Just 20% of teens surveyed say they've met an online friend in person. How do these friends communicate? You guessed it; the majority of that communication is electronic. About 80% use instant messaging, 72% use social media, 64% use email, and 59% use video chat.



ICANN Seeks Input On Plan To End U.S. Oversight Of Internet Names

The United States' control over the IANA (Internet Assigned Numbers Authority) could end soon. Under a new proposal now open for public comment, the "global multistakeholder community" would take control from the U.S. Department of Commerce's National Telecommunications and Information Administration. The idea for the transition, which ICANN says is an "important Internet governance milestone," was first announced in March 2014. It would include three categories of IANA functions: domain names, Internet numbering resources, and protocol parameters.





Job Of The Month

Sprint, the American communications company that now has a Japanese parent in the form of SoftBank, is casting a net for a data scientist for its wholly owned subsidiary Pinsight Media. Pinsight is a mobile data company, so you can understand the connection to Sprint and grandpa SoftBank. As a data scientist for Pinsight/Sprint, you'll use your wonk math and statistical skills to help develop processes and systems for analyzing high-volume data sources (as in REALLY BIG data). This person should have a bachelor's degree and four years work experience, including three years working with advanced math and stats and three years working with various predictive modeling tools and languages such as SAS, SPSS, Python, Java, and R. Ideally, you'll also be a honcho with Hadoop, be learned about Linux, and be mad about machine learning models. This position is for the company's offices in Kansas City, Missouri. If you're interested, see Sprint's website for more . . . uh, data. Go, Royals.

Source: www.sprint.jobs

Maybe They Should Just Ask Ms. Mobile Manners

Society has changed a lot in the past 25 years. Cellphones, digital cameras, and the Internet ushered in the age of "always-on" communications, which has affected our notions of security and privacy. Now some people are questioning whether digital communications also are changing our views about civility and manners. Pew Research surveyed more than 3,000 people to get their opinions about when, where, and how cellphones should be used in specific situations. Among its findings: about 90% of cellphone owners say they frequently carry their phones, and 31% of people never turn off their cellphones. See the table above for more info on when people say it is appropriate to use a cellphone.

Source: *Pew Research*

Percentage of people who say it is OK to use a cellphone in these situations:

Walking down the street	77%
On public transportation	75%
Waiting in line	74%
At a restaurant	38%
At a family dinner	12%
During a meeting	5%
At church or worship service	4%

Who Sells The Most Computers? Here Are The Big 5

According to research firm Canalys, there's a new world leader in terms of total share of the PC market, which encompasses desktops, notebooks, and tablets. Lenovo has overtaken Apple in the top spot, shipping nearly 16 million units during the 2nd quarter of this year. Apple had been in first place since Q3 2014.



Top MFRs By Market Share (Desktops, Notebooks & Tablets) in Q2 2015

Rank	MFR	Market Share
1	Lenovo	15%
2	Apple	14%
3	HP	12%
4	Dell	9%
5	Samsung	8%

Source: *Canalys*

RAW Numbers:

17%

The percentage of smartphone users in the United States who use some sort of messaging app that automatically deletes messages after they are sent.

Pew Research

32.2%

Year-over-year percentage growth forecast for United States retail m-commerce (mobile commerce) sales for this year. The biggest growth in e-commerce (electronic commerce) is being driven by mobile purchases as people become comfortable making purchases with their phones. About 25% of all e-commerce sales will be made on mobile devices by 2016.

eMarketer

14 million

Number of times the Windows 10 operating system was downloaded in the first 24 hours after the program was released to the public.

Microsoft

\$30.6 billion

Forecasted value of the global market for lithium-ion car batteries by the year 2024. The value of the market this year is estimated to be about \$7.8 billion.

Navigant Research



msi



CHOOSE YOUR DESTINY

MSI Z170 GAMING MOTHERBOARDS

9.9



MSI Z170A GAMING M7

"From the box design and down to getting it all up and running, I had a smile on my face all the way. This most definitely is not the MSI of old. Today's MSI is almost perfect." -Techpowerup

US.MSI.COM

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Can We Tock?

Skylake Perfects Intel's 14nm Platform

The PC is undergoing a series of major technological shifts. Gaming at 2,560 is giving way to gaming at 4K, single-monitor setups are being replaced by triple-screen configurations, and DirectX 11.2 is stepping aside for DirectX 12. Additionally, DDR3 memory is being replaced by much faster DDR4, PCIe-based storage devices are becoming more common, and Windows 8.1 is passing the baton to Windows 10.

Whether you are planning a new build or upgrading your current system, it's important to choose a platform designed to embrace these new technologies and ensure the highest performance, the greatest flexibility, and the absolute best experience.

The new 6th Generation Intel Core desktop processors and Intel's Z170 chipset represent the perfect platform to take advantage of all this new tech and change the way you game, stream, create, and work.

Skylake

Code-named "Skylake," Intel's 6th Generation Core processors take Intel's 14nm manufacturing process and refine it for even greater performance. The flagship processor, the Core i7-6700K, is a quad-core CPU with Hyper-Threading technology that allows it to run up to eight instruction threads simultaneously. It has a stock clock speed of 4GHz and a maximum single-core frequency of 4.2GHz through



Intel's Turbo Boost 2.0 Technology, and it's equipped with 8MB of Intel Smart Cache memory.

The second processor in the Skylake lineup, the Core i5-6600K, is also a quad-core chip. It has a base frequency of 3.5GHz (max Turbo frequency of 3.9GHz) and 6MB of Intel Smart Cache.

Both processors provide support for up to 64GB of dual-channel DDR4 memory, both have a 91-watt TDP (thermal design power), and both are equipped with Intel's new HD Graphics 530 processor graphics. Intel HD Graphics 530 runs at a base frequency of 350MHz, with a maximum dynamic frequency of 1.15GHz, and provides 4K support at 60Hz, triple-display support, and support for DirectX 12 and OpenGL 4.4.

In other words, not only are these blazing-fast processors perfect for gaming, editing video, working, multitasking, and more, but they also provide the highest level of graphics output available without a discrete GPU.

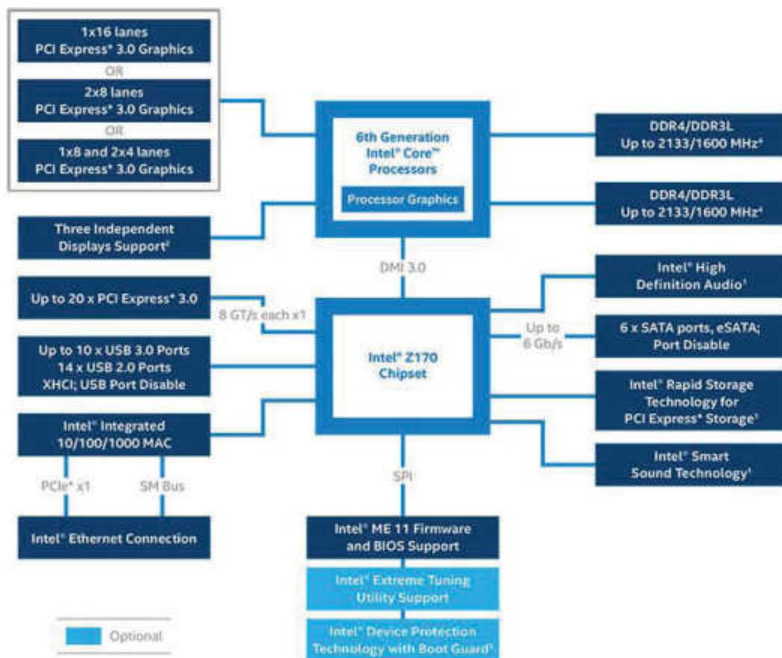
Z170

A good CPU needs a good chipset to unlock its full potential, and for 6th Generation Intel Core processors, that chipset is Z170. Designed to mesh perfectly with the Core i7-6700K and Core i5-6600K, the Z170 chipset provides dual-channel support for DDR4, the fastest desktop memory spec on the market today. DDR4 also operates at lower voltage settings than

DDR3, which adds efficiency to this new platform's list of benefits.

Z170 comes equipped with Intel's new DMI (Direct Media Interface) 3.0, which provides four connection lanes between the CPU and PCH at 8GTps per lane, for a total of nearly 4GBps. Another upgrade from previous chipsets is Z170's larger Flex-IO hub, which increases the number of ports available to motherboard manufacturers for use as PCIe lanes, USB 3.0 ports, or SATA 6Gbps ports from 18 in Z97 to 26. In addition to allowing for greater flexibility in motherboard design, the new hub dedicates more bandwidth to PCIe devices for use with Intel's RST (Rapid Storage Technology), paving the way for more motherboards with

Advertisement



RAID support for SATA Express and M.2 storage devices.

Other supported technologies include Intel Ready Mode Technology (which can keep your system and its applications up-to-date via a constant connection), Intel Smart Sound Technology (an integrated DSP for audio offload and audio/voice features such as voice commands), Intel Device Protection Technology with Boot Guard (protects your system from malicious code prior to the OS launching), and more.

Born To Overclock

Most power users are familiar with Intel's K series processors and their unlocked multipliers, but with Skylake and Z170, Intel has provided the highest level of overclocking control yet. For starters, you have access to unlocked core ratios in 83 100MHz increments, as well as complete Turbo overrides for voltage and power limits. But you also get enhanced full-range BCLK (base clock) overclocking, which allows for adjustments in 1MHz increments up to 200MHz or higher—some sources report frequency gains greater than 400MHz when using

liquid-nitrogen cooling. And in some cases, Z170 motherboard manufacturers will include overclocking utilities that will give you even finer-grained control.

Additionally, the platform provides increased granularity in memory

overclocking, allowing adjustments in 100/133MHz increments, as opposed to the previous generation's 200/266MHz steps. Available DDR frequency overrides allow for memory clocks of up to 4,133MHz and higher. (Intel reports non-typical results of up to 4,795MTps with LN2.) Of course, you will also have access to simplified memory overclocking controls via Intel's XMP 2.0 memory profiles.

Skylake and Z170 also come with an unlocked processor graphics ratio and unlocked voltage controls, the latter of which should allow experts to fine-tune increases in the performance of their CPU without also increasing temps more than necessary.

Look Inside

As the Tock to Broadwell's Tick, Skylake is a big step forward. When teamed up with a Z170 motherboard, the Core i7-6700K and Core i5-6600K give you improved performance, greater power efficiency, increased overclocking control, and support for the latest PC technologies. ■



Heading To Skylake?

Take The Right Board With You

Skylake is proof that good things come to those who wait, as you'll be able to choose between two 6th Generation Intel Core processors with unlocked multipliers that deliver support for dual-channel DDR4 memory. The Core i7-6700K is the flagship model, and it delivers a 4.2GHz Turbo Boost frequency (4.0GHz base clock) and four cores with Hyper-Threading to process up to eight concurrent threads. The flagship chip also comes with 8MB Intel Smart Cache and Intel's HD Graphics 530 featuring 24 execution units. The Core i5-6600K is only slight drop in speed, at a 3.9GHz Turbo Boost frequency and 3.5GHz base clock. Similar to most recent quad-core Core i5 variants, Intel drops Hyper-Threading on the Core i5-6600K, and there's a smaller cache (6MB) than the Core i7-6700K.

The Skylake chips require a different socket (LGA1151) than Broadwell or Haswell (LGA1150), so you'll need a new motherboard to gain entry. Z170 is the enthusiast-level chipset introduced with Skylake, and all the models in this roundup are based on it. To learn more about this new chipset, you can check out "The Mighty Z170" on page 54 of this issue.

The Test System

When benchmarking the motherboards in this roundup, we tested the mainboard using Intel's Core i7-6700K (at stock clocks), ZOTAC's GeForce GTX 780 AMP! Extreme Edition, Crucial's Ballistix Sport DDR4-2400, and Intel's SSD 730 Series 240GB. We're always happy to bench with a new flagship chip, and Crucial's Ballistix Sport is a speedy low-profile memory kit that'll work in most any test bench. You'll be able to find the benchmarks at the end of the roundup, while the upcoming reviews will recap the most interesting features that each manufacturer builds around the Z170 chipset.

GA-Z170X-Gaming G1

\$499 | GIGABYTE | www.gigabyte.us



Specs: Max memory: 64GB DDR4 (DDR4-2133, Max OC: DDR4-3666); Slots: 4 PCIe x16, 3 PCIe x4; Storage: 10 6Gbps SATA, 3 SATA Express, 2 M.2 (socket 3); Rear I/O: 1 HDMI, 2 USB 3.1 (one Type-C, one Type-A), 7 USB 3.0, 1 USB 2.0, 1 PS/2, 1 optical S/PDIF out, audio I/O, 2 Ethernet, 2 antenna connectors; Form factor: E-ATX; Warranty: 3 years

GIGABYTE GA-Z170X-Gaming G1

Let's get this out up front—the GA-Z170X-Gaming G1 is \$499. Now, before you think about skipping to the next review, this is possibly one of the most feature-filled boards you'll ever find. There's support for 4-way SLI and CrossFire (at x8/x8/x8/x8), and both cards in a two-way GPU configuration will operate at the full x16 speed. For storage, the G1 provides a plethora

of options with three SATA Express ports operating at 16Gbps, two M.2 slots that work at up to 32Gbps, and support for U.2 storage devices via the included M.2 to U.2 adapter. The VRM is also ready for liquid cooling.

GIGABYTE also steps up its game when it comes to USB 3.1 support. To start, there are two USB 3.1 ports on rear panel—one standard Type-A USB connector and the reversible Type-C connector. The USB 3.1

ports are powered by Intel's USB 3.1 controller that offers a maximum bandwidth of 32Gbps, so bandwidth won't be limited if both 10Gbps USB 3.1 ports are active. The G1 also comes with a 5.25-inch front panel bay that adds another USB 3.1 Type-A and Type-C connector. The USB 3.1 bay does require one of the board's SATA Express ports, but you'll still have two left over, which is equivalent to or more than what you'll find on other Z170 motherboards.

For audio, GIGABYTE implements Creative's Sound Core3D quad-core audio processor that can deliver a 192KHz/24-bit audio signal. The discrete-level audio fidelity is further enhanced by Nichicon and WIMA audio caps and a front-panel headphone amplifier that supports up to 600ohm headphones. Want to customize the sound? GIGABYTE offers switchable OP-AMPS for the rear left and rear right channels, as well as an OP-AMP for the front audio jack. Creative's SBX Pro Studio software suite rounds out this impressive audio feature list.

You'll find a host of onboard overclocking capabilities on the G1. There are voltage read points, a POST code display, main and backup BIOS chips, and power, reset, and clear CMOS buttons. GIGABYTE also adds a Turbo B-Clock IC, which lets you fine-tune the BCLK (base clock) frequency beyond the 5% ranges of traditional straps. Those loading up their rig with heavy GPUs will like that GIGABYTE uses stainless-steel shielding to reinforce the PCIe connectors. GIGABYTE indicates that in shearing tests, the PCIe slots are 1.7 times stronger with the shields.

As you might imagine, the G1 breezed through our benchmarks. It took top honors in 3DMark's Fire Strike Extreme with the best Score (6510), Graphics Score (6858), and Physics Score (12768). It was also one fps faster, on average, than the competition in The Witcher 3 with 46fps. On the whole, the G1 did well in our CPU-intensive tests, and it posted top marks in SiSoftware's Sandra 2015's Memory Bandwidth tests with 29.12GBps in the Integer test and 29.13GBps in the Floating test.

The GA-Z7170X-Gaming G1 certainly falls under the "spare no expense" category, yet it's more than a showcase piece. It's ready for anything you throw at it and then some.

MSI Z170A XPOWER GAMING TITANIUM EDITION

MSI's XPOWER series is geared towards overclockers, so it's no surprise that the Z170A XPOWER GAMING TITANIUM EDITION comes with voltage check points, an integrated clock generator that adds flexibility to your BCLK strap, and MSI's premium Military Class power-handling components. We've come to expect these power user additions to MSI's XPOWER lineup.

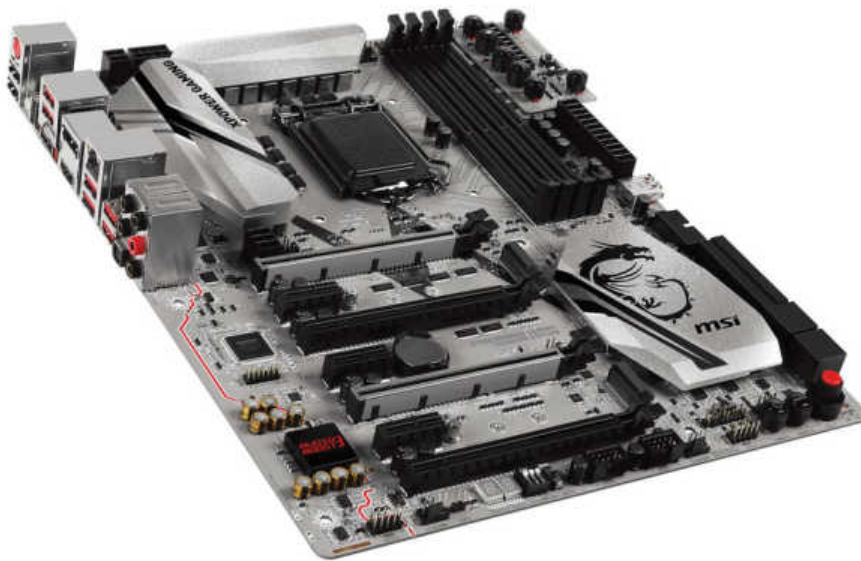
MSI raises the ante with the TITANIUM EDITION, however, by making it easier to access and manage overclocks. MSI includes an external OC Dashboard panel that connects via its own cable, so you'll enjoy the convenience of push-button control of the CPU ratio and BCLK without having to reach inside the case. The OC Dashboard also lets you reset the BIOS, clear the CMOS, and power down the PC. If you prefer to make adjustments in the OS, you can use MSI's Gaming Hotkey feature that uses a dedicated hardware chip to let you assign OC profiles and program OC commands, such as increasing or decreasing the CPU ratio.

The TITANIUM EDITION's overclocking chops extend beyond the CPU, as it supports DDR4 clocked at up to 3,600MHz. MSI is able to reach such lofty speeds in part because of its DDR4 Boost technology that isolates the memory circuitry; the company reports that overclockers have achieved a 4,605MHz memory clock speed on the TITANIUM EDITION.

Previous iterations of MSI's XPOWER series featured a yellow and black color scheme, but the TITANIUM EDITION is a complete departure, with its stunning silver and black look highlighted by a metallic silver PCB. MSI further complements the silver PCB with its Steel Armor on two of the PCIe x16 slots, which MSI says helps to prevent damage to the slots. The board supports up 2-way SLI and 4-way CrossFire. (In 4-way CrossFire, the four cards run at x8/x4/x4/x4.)

Z170A XPOWER GAMING TITANIUM EDITION

\$299.99 | MSI | us.msi.com



Specs: Max memory: 64GB DDR4 (DDR4-2133, Max OC: DDR4-3600); Slots: 4 PCIe x16, 3 PCIe x1; Storage: 8 6Gbps SATA, 2 SATA Express, 2 M.2 (type 2242/2260/2280); Rear I/O: 2 HDMI, 1 DisplayPort, 2 USB 3.1, 4 USB 3.0, 3 USB 2.0, 1 PS/2, 1 optical S/PDIF out, audio I/O, 1 Ethernet, 1 Clear CMOS button; Form factor: ATX; Warranty: 3 years

Next-generation storage—both internal and external—is part of the package, too. There are two M.2 ports that both support a maximum theoretical bandwidth of 32Gbps, two SATA Express ports that operate at up to 16Gbps, and eight 6Gbps SATA ports. An U.2 host card is separately available, if you want to add support for NVMe storage devices. For external storage and peripherals, you'll find two USB 3.1 ports (Type-A, rear), 7 USB 3.0 ports (4 rear, 2 internal, and 1 for OC Dashboard), and 7 USB 2.0 ports (3 rear, 4 internal). (Note that MSI refers to the USB 3.0 ports as "USB 3.1 Gen1" ports in the user manual, but the ports operate at the 5Gbps maximum of USB 3.0.)

The onboard audio is worth noting, as well. Many of MSI's Z170 motherboards come with Audio Boost 3, which is powered by Nahimic Sound Technology's software. This software provides virtual 7.1 surround sound, mic noise reduction, intensified bass, and more.

The TITANIUM EDITION performed like a champ in our benchmark tests. It posted top marks in most all of SiSoftware

Sandra 2015's Processor Arithmetic and Processor Multi-Media tests, as well as the best scores in Cinebench 15 (907 points) and POV-Ray 3.7 (1908.42 pixels per second). In our game tests, it posted the highest frames per second in Dying Light (72.3fps), so it's clearly more than a one-trick pony. In CrystalDiskMark, the TITANIUM EDITION also registered the best transfer rates in the Sequential Read tests.

If you're serious about overclocking your Skylake processor and want to wring the best possible performance from it, the Z170A XPOWER GAMING TITANIUM EDITION should be at the top of your list. MSI gets the best out of your hardware and provides you with tools that simplify the overclocking process.

Supermicro C7Z170-SQ

With the arrival of Skylake, Supermicro has launched a new motherboard product family, titled Supero, and the C7Z170-SQ is the flagship of the group. The

C7Z170-SQ looks the part, with a red and black color scheme that easily makes this the most attractive board we've seen from the company to date. The C7Z170-SQ also has all the goodies we'd expect, including a USB 3.1 Type-C port and an M.2 port.

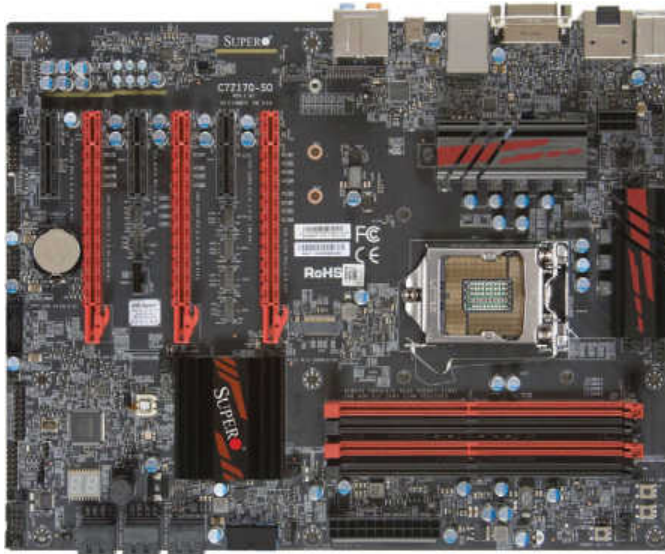
Supermicro ports much of its server expertise over to the gaming arena with the Supero family. For example, the PCB is designed with extra layers and using material qualified by Supermicro's server standards. Top-grade X5R or X7R ceramic chip capacitors populate the motherboard to help withstand heat, while Japanese NPCAP solid-state capacitors deliver low equivalent series resistance and outstanding ripple reduction, according to Supermicro. The result is improved stability when overclocking and greater reliability in general. Lastly, the Supero motherboards are validated using Supermicro's full-load server testing, which includes 100% loads for at least 150 hours.

The C7Z170-SQ allows for fine-tuning of the BCLK, which can be adjusted from 100MHz to up to 210MHz in 1MHz increments. Onboard power, clear CMOS, and BIOS Restore buttons allow you to easily recover from any overclocking missteps. We also like that the C7Z170-SQ comes with a new, modern UEFI BIOS interface. When overclocking, it's now extremely easy to make quick adjustments to the clock speed, BCLK ratio, and voltages, for instance. You can run DDR4 clocked at up to 3,600MHz, and the board's four DIMM slots can handle up to 64GB of memory.

When it comes to graphics, the C7Z170-SQ sports the triple-PCIe x16 slot configuration that is common among Z170 motherboards in the \$200 price range. Dual GPU setups will run at x8/x8 speed, and three-way CrossFire is supported at x8/x4/x4. Supermicro made an interesting choice with the position of the M.2 connector, which is above the top PCIe x16 slot, rather than in between PCIe slots near the bottom of the PCB. And first blush, the design would seem to unnecessarily compress the PCIe x16 slots, but the open space could be extremely helpful if you wish to use the M.2 slot for an M.2-to-U.2 adapter. There are also three PCIe x4 slots, but we'll note that two of the x4 slots are wired for x1 speed.

C7Z170-SQ

\$209.99 | Supermicro | www.supermicro.com/gaming



Specs: Max memory: 64GB DDR4 (DDR4-2133, Max OC: DDR4-3600); Slots: 3 PCIe x16, 3 PCIe x4; Storage: 6 6Gbps SATA, 1 M.2 (type 2260/2280/22110); Rear I/O: 1 HDMI, 1 DisplayPort, 1 DVI-D, 1 USB 3.1 (Type-C), 2 USB 3.0, 2 USB 2.0, 1 PS/2, 1 optical S/PDIF out, audio I/O, 1 Ethernet; Form factor: ATX; Warranty: 3 years

Z170-A\$165 | ASUS | www.asus.com

Specs: Max memory: 64GB DDR4 (DDR4-2133, Max OC: DDR4-3400); Slots: 3 PCIe x16, 3 PCIe x1, 1 PCI; Storage: 6 6Gbps SATA, 1 SATA Express, 1 M.2 (type 2242/2260/2280/22110); Rear I/O: 1 HDMI, 1 DisplayPort, 1 DVI-D, 1 VGA, 2 USB 3.1 (one Type-C, one Type-A), 2 USB 3.0, 2 USB 2.0, 1 PS/2, 1 optical S/PDIF out, audio I/O, 1 Ethernet; Form factor: ATX; Warranty: 3 years

Supermicro's C7Z170-SQ delivered the top frame rate in Aliens vs. Predator (64.5fps) and was near the top for many of the other graphics tests, including 3DMark's Fire Strike Extreme, where it delivered a Score of 6465 and a Graphics Score of 6840. The C7Z170-SQ also posted the highest Sequential Write speeds in CrystalDiskMark 5.0.2 and did well in the 4K Write tests.

Reliability is always going to be a key benefit for Supermicro's products, and this board shows off how well Supermicro can take those stability additions and translate them over to better overlocks. Onboard controls, such as the BIOS Restore button and debug LED, further enhance the experience. There's also enough core additions for performance enthusiasts, including the 32Gbps M.2 and USB 3.1 Type-C ports, to allow for component flexibility in the future.

ASUS Z170-A

At \$165, power users might dismiss ASUS' Z170-A as a budget-friendly Z170 motherboard, but one look at the board's

big heatsinks tells you this is not a run-of-the-mill board that merely replicates the stock Z170 chipset. In particular, ASUS adds several overclocking and system optimization enhancements. The PRO Clock technology, for instance, is a dedicated base-clock control that works with the ASUS TPU (Turbo Processor Unit) to let you increase performance. With PRO Clock, you can extend the BCLK overclocking range well past Skylake's standard 170MHz.

If you'd rather, though, you can use ASUS' 5-way Optimization to auto-tune your system. You can even set targets for CPU frequency and voltage, as well as temperature limits, so 5-way Optimization can help you reach specific performance objectives. One of our favorite features is the Turbo App, where you can save various overclocking profiles and assign network priorities to quickly load the ideal presets for the task at hand.

Gamers will be able to load up the Z170-A with high-powered GPUs. There are three PCIe 3.0 x16 slots, and ASUS allows for up to quad-GPU SLI or CrossFire

with dual-GPU graphics cards. If you plan on using single-GPU cards, the Z170-A supports a maximum configuration of 2-way SLI (x8/x8) and 3-way CrossFire (x8/x4/x4). (If you are considering a 3-way CrossFire build, be aware that the bottom PCIe x16 slot shares bandwidth with the fifth and sixth SATA ports.) The Z170-A also offers three PCIe x1 slots and one legacy PCI slot.

The Z170-A is ready for high-capacity, high-speed DDR4. You can install up to 64GB of DDR4-3400 memory. ASUS uses its second-generation T-Topology that provides a customized trace layout, which the company says reduces crosstalk and coupling noise for better stability and compatibility.

When it comes to cooling and system noise, ASUS gives you complete control of the fans, as well as the water pump headers, inside its UEFI BIOS. For example, you can control fan speed and fan spin down time to prevent rapid fluctuations in fan speed and noise.

Storage enthusiasts will like that the Z170-A includes native M.2 and NVMe RAID 0 support. You can even create a RAID from a mix of M.2 storage and a PCIe add-in storage card. The onboard M.2 slot supports both SATA- and PCIe-based storage devices (types 2242/2260/2280/22110). There's also a SATA Express port and six 6Gbps SATA ports. Above the third and fourth SATA ports, ASUS smartly adds an "OS Drive" sticker to forestall booting from the fifth and sixth SATA ports, which share bandwidth with the bottom PCIe x16 slot. Next-gen external storage is supported with two USB 3.1 ports on the rear panel. One port is of the reversible Type-C variety and the other is a standard Type-A port.

High-fidelity audio is delivered by ASUS Crystal Sound 3. Here, you'll find all of the big-time features with modern onboard audio, including audio shielding on the PCB, EMI protection, onboard amplification, and power regulation for a consistent, clean sound.

The ASUS Z170-A might be up against higher-priced competition, but you wouldn't know it from the benchmarks. This board delivered the top score in PCMark 8's Creative Test (4865) and was second in many of Sandra's processor-intensive

benchmarks. ASUS T-Topology advantages shine through in SiSoftware Sandra's Memory Bandwidth benchmarks, where the Z170-A produced 28.89GBps in the Integer test and 28.73 in the Floating test. Overall, the Z170-A did well in our game benchmarks, and it posted the best frames per second in Metro: Last Light (62fps).

Despite its budget-friendly price tag, the Z170-A incorporates several of the most helpful hardware enhancements from ASUS' higher-end motherboards, such as the PRO Clock, T-Topology, and 5-way Optimization features. The hardware and software additions allow performance enthusiasts to push the envelope, while smart design choices (such as the M.2 port that supports both SATA- and PCIe-based storage) maximize component flexibility without raising costs. Props to the ASUS team on a job well done.

Your Skylake Starter

Motherboard manufacturers are getting smarter about tailoring their motherboards to suit a specific audience. This roundup, for example, includes something for the extreme gamer with the GIGABYTE GA-Z170X-GAMING G1, as well as an overclocker-centric option with MSI's XPOWER GAMING TITANIUM EDITION. Supermicro's C7Z170-SQ delivers superb reliability with server quality parts, and ASUS' Z170-A is a shining beacon for the term "budget-friendly." Best of all, these are just the initial Z170 motherboard launches, so we can already tell that Skylake is going to be a fun ride. You may now commence building. ■

BY NATHAN LAKE

Benchmark Results	GIGABYTE GA-Z170X- Gaming G1	MSI Z170A XPOWER TITANIUM	Supermicro C7Z170-SQ	ASUS Z170-A
Price	\$499.99	\$299.99	\$209.99	\$165
3DMark Professional (Fire Strike Extreme)				
Score	6510	6390	6465	6455
Graphics Score	6858	6782	6840	6834
Physics Score	12768	11805	11900	12574
Combined Test	14.32	14.01	13.8	14
PCMark 8				
Creative Score	4822	4801	4741	4865
SiSoftware Sandra 2015				
Dhrystone Integer Native AVX2 (GIPS)	198.56	207.38	193.67	197.22
Whetstone Single-float Native AVX (GFLOPS)	110.3	114.36	108.56	109.16
x32 Multi-Media Integer AVX2 (Mpixels per second)	391.45	409.62	393.78	395.12
x16 Multi-Media Long-int AVX2	182.91	191.3	179.88	182.65
x1 Multi-Media Quad ALU	2.15	2.25	2.11	2.15
x16 Multi-Media Single-float FMA	368.3	386.66	372.12	379.1
Integer Memory Bandwidth B/F AVX/128 (GBps)	29.12	28.5	28.46	28.89
Floating Memory Bandwidth B/F AVX/128 (GBps)	29.13	29.07	28.77	28.73
Cinebench 15 CPU score (points)	881	907	870	873
POV-Ray 3.7 (pixels per second)	1888.28	1908.42	1870.88	1880.34
CrystalDiskMark 5.0.2				
Sequential Read (Q32T1)	550.9	560.4	554.6	556
Sequential Write (Q32T1)	298.4	292.2	299.9	262
4K Read (Q32T1)	146.4	169.4	141.2	165.2
4K Write (Q32T1)	127.3	163.1	132.7	150.7
Games (2,560 x 1,600)				
Metro: Last Light (16xAF; SSAO off)	61	60.7	61	62
Aliens Vs. Predator (8XAA, 16xAF)	64.1	63.2	64.5	64.4
Dying Light (Med, AO On, AA On, Vsync Off)	71.4	72.3	71.5	71.4
The Witcher 3 (Vsync off, Unl.fps, Ultra)	46	43	44.1	45



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Cooler Master MasterCase 5 & MasterCase Pro 5

If you build your own PCs, you have no doubt thought on at least one occasion (but probably several more than one): “This case would be great if it just had more room up top for a radiator,” or “If only I could take all of the internal drive cages out,” or “Wow, if this case had a windowed side panel, it would be perfect.” It seems like no matter how careful you are in choosing the right chassis, you always end up compromising a little.

With that in mind, Cooler Master developed its new MasterCase chassis series, which currently includes the MasterCase 5 and MasterCase Pro 5. (We talked with Cooler Master’s Rajiv Kothari about the case in the July issue (page 79) and got some further insights from master modders Richard Surroz and Lee Harrington in the August issue (page 86).)

Spending some time with this enclosure makes it readily apparent that experienced PC builders and modders were involved in its design. Yes, all of the standard amenities are in place, such as rubber-grommeted cable management holes, a cutout for mounting a CPU cooler, tool-less drive bays in removable cages, and so on, but that’s where most cases

would call it a day. The MasterCase 5 is just getting warmed up.

Cooler Master also built in a very handy vertical conduit that runs from the top of the rear of the motherboard tray to very nearly the bottom (just forward of the cable management holes) for managing cables even more neatly. This conduit makes it easy to control the sprawl of cables that run from behind the front panel, as well as others, and there are three built-in nylon and Velcro straps along the channel that keep everything where you put it.

Both of the internal drive cages come out with the removal of just a few thumbscrews—this is also pretty standard these days. But if you’d rather move the two 3.5-inch drive bays in the lower cage than remove them, the MasterCase 5’s internal front rails lets you adjust their position all the way down to the shelf that separates the interior into two compartments: one for the power supply and one for the motherboard and other components. This shelf includes two more cable management openings, and on its top surface are two dedicated 2.5-inch drive mounts. If you prefer your drives out

of sight, you can remove the thumbscrews that hold them in place and relocate them to the back of the motherboard tray. There’s also a single, removable 2.5/3.5-inch mount at the front end of the PSU compartment, so regardless of how you configure your MasterCase 5, you’ll have options for mounting your drive(s).

The MasterCase Pro 5 takes all of the standard edition’s refinements and adds a few more through the inclusion of several additional parts. (The good news is that these accessories will be also be available soon via Cooler Master’s online store, so if you get the MasterCase 5 and then decide you’d like to upgrade, you can easily do so.) The most obvious additional parts are the windowed left-side panel and the vaulted, ventilated top panel that comes with a bracket for mounting a 240mm radiator. The MasterCase Pro 5 also includes three more 2.5/3.5-inch internal drive bays in the form of an additional cage, and more cages and 2.5-inch mounting plates are available, as well.

Cooler Master didn’t neglect aesthetics when building all of this functionality into the MasterCase 5 and MasterCase Pro 5; the dark grey exterior looks great in both configurations, and the interior is fully finished, too. And both trim levels benefit from the steel handles riveted to the frame beneath their plastic cowlings; they are sturdy and make moving your system much simpler. In short, it looks as though Cooler Master—and the MasterConcept team—have thought of everything. ■

BY CHRIS TRUMBLE

MasterCase 5/MasterCase Pro 5

\$109.99/\$139.99

Cooler Master

www.coolermaster.com

Specs (MasterCase 5): Dimensions: 20.2 x 9.25 x 21.6 inches (HxWxD); Materials: SECC steel, plastic; Motherboard support: Mini-ITX, mATX, ATX; Drive bays: 2 x 5.25-inch external, 3 x 3.5-inch/2.5-inch internal, 2 x 2.5-inch internal; Fans (included): 1 x 140mm front, 1 x 140mm rear; Fans (optional): 3 x 120/140mm front, 2 x 120/140mm top, 1 x 120/140mm rear; Ports: 1 x USB 3.0, audio I/O



Anarchy X DDR4-2800 / \$124.99
PNY / www.pny.com

PNY Anarchy X DDR4-2800

Skylake is finally here (kinda, retail availability was nonexistent as we went to press), and as a result, mainstream users' interest in DDR4 is likely to rise in the coming months. DDR4 memory prices have also dropped to the point that the speed increase and power decrease compared to DDR3 make the newer specification an obvious choice. Indeed, it's a great time to buy memory, and PNY is looking to make the most of this impending tidal wave of DDR4 buyers with its new 16GB Anarchy X DDR4-2800 kit.

PNY's kit consists of four 4GB matched modules. Although this setup is ideal for a quad-channel memory rig, it'll work just fine in a dual-channel Z170-based motherboard.

This is one of the more affordable DDR4 kits we've tested, but it still manages to support Intel's XMP 2.0, which makes overclocking the memory to 2,800MTps (megatransfers per second) a simple matter of changing a single setting in the BIOS. By default, the memory will boot at 2,133MTps, but Profile #1 unleashes this kit's full potential. The Anarchy X kit also supports 2,666MTps and 2,400MTps speeds. At its highest

rated speed, this kit still just calls for 1.2V. The timings are also pretty solid, at 16-16-16-36.

The heatspreaders on the Anarchy X consist of colored aluminum plates. Two anodized black plates make up a majority of the heatspreader and a central clip, available in anodized blue or red, holds the two halves together. The black plates are adorned with Anarchy X, PNY, and DDR4 logos. The PCB is 3.1mm tall and the heatspreader adds just 1.1mm to the overall profile, making this kit ideal for those planning to use oversized CPU coolers. The memory kit also comes with a lifetime warranty.

In SiSoft Sandra 2015 SP2, the integer and floating point memory bandwidth scores were 53.67GBps and 55.13GBps, respectively. We also ran Sandra's memory latency workload, which measures how long it takes to transfer a block of data from main memory. In this test, the Anarchy X kit scored a very impressive 25.6 nanoseconds. Our low resolution Aliens Vs. Predator run, designed to isolate the CPU and memory performance, yielded a 750.9fps score. That doesn't mean much on its own, but when we underclocked

Benchmarks	16GB PNY Anarchy X DDR4 -2800
Price	\$124.99
Timings	16-16-16-36
Voltage	1.2V
Modules	4 x 4GB
SiSoftware Sandra Lite 2015. SP2	
Memory Bandwidth	
Integer Memory Bandwidth B/F AVX2/256 (GBps)	53.67
Floating Memory Bandwidth B/F FMA/256 (GBps)	55.13
Cache & Memory Latency (ns)	25.6
L1D (clocks)	4
L2D (clocks)	13
L3D (clocks)	27.6
Cache Bandwidth (GBps)	297.68
L1D (TBps)	1.44
L2 (GBps)	520.72
L3 (GBps)	222
Game	
Aliens VS. Predator (Low, 1XAF, No AA, 800 x 600)	750.9fps

the memory to 2,133MTps, the score dropped almost 100fps, to 657.7fps.

For its affordable price, impressive performance, and sharp aesthetics, PNY's 16GB Anarchy X DDR4 kit should occupy a top slot on your new parts list. ■

BY ANDREW LEIBMAN

Specs: Capacity: 16GB (4 x 4GB); Timings: 16-16-16-36; Frequency: DDR4-2800 (PC4-22400); Voltage: 1.2V; Unbuffered; Non-ECC; Warranty: Lifetime



ZOTAC GTX 980 Ti AMP! Extreme Edition

This month, ZOTAC sent us the highest factory overclocked 980 Ti we've tested to date, the GTX 980 Ti AMP! Extreme Edition. But before we explore the particulars of this card, let's recap what NVIDIA brings to the table with its Maxwell-based flagship GPU.

This GM200 GPU features 8 billion transistors crammed into a 601 square mm die made using a 28nm process. The 22 streaming multiprocessors in the GTX 980 Ti lend this card 2,816 CUDA cores, 176 texture units, and 96 ROPs. Compared to NVIDIA's older Kepler architecture, this chip yields double the performance-per-watt. On that topic, this card has a 250-watt TDP and requires a pair of 8-pin PCIe power connectors to run. To enjoy this beast, make sure your PSU can handle at least 600 watts of continuous power.

The memory subsystem of the GTX 980 Ti is very capable, even compared to NVIDIA's other high-end cards currently available (save the 12GB TITAN X). There are 6GB of GDDR5 memory running on a 384-bit memory bus. The quad-piped memory on the stock version of the GTX 980 Ti is clocked at 1,752MHz, but ZOTAC has overclocked it by 53MHz to 1,805MHz. Although that doesn't sound like much, it's the highest memory clock we've seen yet on the 980 Ti and it's more

than enough to let you enjoy playable framerates in most games running at 4K resolutions. If you plan to run this card while connected to a 4K display, you'll be able to use any of the three DisplayPort outputs or the HDMI output to do it. There's also a DVI port on the card for legacy monitors with resolutions up to 2,560 x 1,600.

One of the best things about this card is the factory overclock; the stock core and boost clocks are 1,000MHz and 1,075MHz, respectively, but ZOTAC's card is clocked at 1,253MHz and 1,355MHz, respectively. We already know that it takes two 8-pin PCIe power connectors to supply the power, but ZOTAC's oversized IceStorm cooler is what enables the GTX 980 Ti AMP! Extreme to hit those impressive core and boost clock numbers. There are a trio of 90mm EKO fans with multi-angle blades, a handful of large-diameter copper heatpipes to rapidly pull heat from the GPU, and a pair of aluminum finned heatsinks under ZOTAC's signature carbon ExoArmor shroud. The card measures more than two inches thick and just over 12-inches long.

Other things we love about this card are the painted aluminum backplate and the OC Plus power regulation controller, which is an isolated PWM controller that lets you

Specs & Scores	ZOTAC GTX 980 Ti AMP! Extreme Edition
Core/Boost Clocks	1,253MHz/1,355MHz
Memory Clock	1,805MHz
Memory Interface	384-bit
Memory	6GB GDDR5
3DMark Professional (Fire Strike Extreme)	8684
Graphics Score	9082
Physics Score	16130
Graphics Test 1	50.36
Graphics Test 2	32.48
Physics Test	51.21
Combined Test	19.99
Unigine Heaven 4.0 Score	2126
FPS	84.4
Games	1,920 X 1,080
Aliens VS. Predator (Very High, 16XAF, 4XAA, SSOA)	157.5
Metro: LL (DX11, Very High, 16XAF, Very High Tess.)	124
Dying Light (High, AO On, AA On, Vsync Off)	159.76
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	85.39

monitor the card's stats, tweak voltages, and take your overclocking to the next level with the help of ZOTAC's Firestorm software. There's a 2-year warranty on this card, but if you register it online, you can get it covered for a third year.

As you can see in the benchmarks, this card is the real deal. If you're looking for a blazing fast GTX 980 Ti, with enough cooling capacity to handle even higher clocks, this is your best bet. ■

BY ANDREW LEIBMAN

GTX 980 Ti AMP! Extreme Edition
\$699.99
ZOTAC / www.zotac.com

Specs: GPU: Maxwell GM200; Core Boost/Base Clocks: 1,355MHz/1,253MHz; Memory Clock: 1,805MHz; Memory Bus: 384-bit; Frame Buffer: 6GB GDDR5; Factory Overclocked: Yes; Ports: dual-link DVI, HDMI, three DisplayPort

Test system specs: Processor: Intel Core i7-5960X; Motherboard: GIGABYTE X99-Gaming G1; RAM: 16GB Ballistix Elite DDR4-2400; Storage: 240GB OCZ Vertex 3 MAX IOPS SSD; OS: Windows 8 Enterprise (64-bit)



In Win 805

Generally speaking, predictability isn't a terribly desirable trait for a company hoping to win the favor of discriminating enthusiasts. For In Win, though, being predictable is high praise, because its cases are predictably unpredictable. Year after year, it seems like In Win introduces a handful of cases that find new and unexpected ways to impress. The 805 happens to be the latest, and, of course, it's magnificent.

If it feels like you've seen the 805 before, let us confirm your suspicions: This isn't the first time In Win has used tempered glass side panels. Last year, we reviewed the Mini-ITX 901 chassis (see page 19 in the March 2014 issue) and used the midtower 904 to kick off the 2014 season of "CPU System Workshop"

(see page 33 in the February 2014 issue), and since then In Win has released several other cases that make use of tempered glass. The side panels of the 805 are tempered glass, and only tempered glass. In fact, the 805 distinguishes itself from In Win's 90X cases by adding even more tempered glass. The 805's front panel is glass, too, save for the thin strip of brushed aluminum at the top, where you'll find the case's power button and I/O ports. Here, In Win presents buyers with three color choices; the strip of brushed aluminum is either gold (pictured), red, or black. The 805's top panel is also brushed aluminum.

The rest of the 805's chassis is also aluminum, which makes the case both

lightweight and sturdy. We can't argue with the construction.

For as visually arresting as the 805 is, it's also surprisingly accommodating for builders. There are pre-cut holes for routing cables nearly everywhere you could ask for, including the upper left and right corners, on the motherboard tray. In Win also packages the 805 with five cable retention clips with adhesive backing, so you can stick them to the back of the case's motherboard tray exactly where they're needed. (Because the tempered glass side panels make clean cable routing critical on both sides of the motherboard tray, providing the ability for builders to create a custom cable conduit is a huge feather in the 805's cap.) You can reorient the tool-less drive cage so that the trays run perpendicular to the bottom panel or you can remove it entirely. The latter is a viable option, since the 805 has mounts on the back of the motherboard tray for up to three 2.5-inch drives. (The drive cage itself has a fourth 2.5-inch drive mount.)

The 805 is replete with other power user perks. Radiators up to 280mm are welcome inside the chassis, provided the thickness doesn't exceed 60mm. Likewise, you can install graphics cards up to 12.6 inches long. The version of the 805 we reviewed included a Type-C USB 3.1 port, giving you access to the standard's juicy 10Gbps data rate. An alternate version of the case swaps this port for a standard USB 3.0 port. All versions of the 805 have at least one USB 3.0 port, plus two USB 2.0 ports and headphone and mic jacks.

All of this adds up to a case that will induce double takes without zeroing out your bank account. Available for a perfectly reasonable \$199, the 805 is, predictably, another In Win winner. ■

BY VINCE COGLEY

805

\$199

In Win | www.inwin-style.com

Specs: Dimensions: 18.7 x 8 x 18 inches; Materials: Aluminum, 3mm tempered glass; Motherboard support: Mini-ITX, microATX, ATX; Drive bays: 2 x 2.5/3.5-inch internal, 4 x 2.5-inch internal; Fans (included): 1 x 120mm rear; Fans (optional): 2 x 120mm/140mm front, 2 x 120mm bottom (with HDD cage removed); Ports: 1 x USB 3.1 (type C), 1 x USB 3.0, 2 x USB 2.0, audio I/O



Tt eSPORTS COMMANDER Gaming Gear Combo

We've said it before and we'll say it again: Just because you're on a budget doesn't mean you have to settle for components that look cheap, perform poorly, or worse—both. With a little research and patience, though, you can find solid hardware that won't bankrupt you. Tt eSPORTS understands this, making quality gaming gear available for every gamer, including those whose wallets contain little more than a driver's license and a handful of half-completed customer loyalty punch cards. The COMMANDER Gaming Gear Combo is a terrific example of how Tt eSPORTS has extended its stable of products to every income bracket.

The COMMANDER combo is a dynamic duo consisting of a sharp-looking keyboard and mouse. There's no question that this set looks the part. Both input devices have LED backlighting (blue, in this case), a staple of the LAN party scene. On the keyboard, that means LED backlighting

at the base of each key, plus the attractive design flourishes on both sides and Tt eSPORTS' logo, complete with the Battle Dragon, at the top. The mouse also sports a backlit Battle Dragon, and two thin strips of translucent plastic that flank the palm rest also have LED backlighting.

Everything on the keyboard that isn't LED-backlit looks awesome, too. Tt eSPORTS has designed the keyboard to look as though strips of copper have been fastened to the edges with hex key bolts. The majority of the keyboard's surface is swathed a soft-touch rubber coating that's become popular on a lot of enthusiast cases; the same substance coats the top of the COMMANDER combo's mouse. Both the keyboard and mouse have braided cords to prevent tangling. If you want to dress up the keyboard even more, you can purchase separately a set of Tt eSPORTS' METALCAPS, which are zinc alloy keycaps that have been anodized and UV-coated,

to replace the keycaps commonly used for games (WASD, QWER, and the arrow keys).

Using what Tt eSPORTS calls "plunger switches with mechanical keycaps," the keyboard is built to feel like a much more expensive mechanical keyboard. After using the COMMANDER keyboard, we'd say the overall experience falls between a mechanical keyboard and a typical rubber dome or membrane keyboard. To clarify, though, the action was far crisper than the latter two types of keyboard and certainly better than anything else you'll find in this price segment, where the competition's offerings are almost always a squishy, unsatisfying mess. Tt eSPORTS even includes a few bonuses you might not expect, such as a Windows key lock and repeat rate adjustment.

For such a nice keyboard, you could consider the COMMANDER's mouse a bonus, but it's a capable component in its own right. It has four DPI settings (800, 1,200, 1,600, and 2,400), and you can switch between them on the fly. The sculpted sides felt great in our hand. In addition to the main right and left buttons, the scroll wheel, and the DPI button, the mouse has a pair of thumb buttons on its left side. In use, it moves well and clicks well, so as long as you don't need a bunch of buttons and extensive macro support, the mouse should be up to the task.

Even if the COMMANDER combo's keyboard and mouse were half as good as they are, for 30 bucks they're an incredible deal. (We would've gladly paid that for the keyboard alone.) Budget builders and thrifty gamers should keep the COMMANDER in their sights. ■

BY VINCE COGLEY

COMMANDER Gaming Gear Combo

\$29.99

Tt eSPORTS

usa.ttesports.com

Specs (keyboard): Switch type: Plunger; Polling rate: 1,000Hz; Antighosting keys: Yes; Onboard memory: N/A; Backlit: Yes (blue); Interface: USB; 8 multimedia keys

Specs (mouse): Sensor: Optical (800/1,200/1,600/2,400dpi); Blue LED lighting; 6 buttons; Weight: 4.48oz.; Cable: 70.1 inches, braided



Aerocool VX-700

For the most part, you want a PSU to deliver reliable power, operate quietly, and be unobtrusive inside your case. Aerocool's VX-700 delivers on those points, thanks to the use of high-quality components and a 120mm thermally controlled fan. Under full load, Aerocool indicates the VX-700 will generate a mere 32.5dBA. The unit itself is almost entirely black, without even a label on the top of the unit to distract from the other components inside your case. As such, it's ideal for builders who are looking for a nondescript power supply.

Aerocool targets the VX-700 at entry-level system builders and prices it accordingly at \$69.99, which makes it one of the most affordable 700-watt PSUs around. The VX-700 is designed with one +12V rail that supports a maximum current of 54A, which works out to a maximum wattage of 648W. The +3.3V rail can handle up to 22A, while the +5V rail can pump out 18A. The +3.3V and +5V rails support a combined maximum wattage of 130W.

Aerocool designs the VX-700 to work with the C6/C7 power-saving mode of Intel's Haswell processors, too.

Similar to most every entry-level power supply, all of the VX-700's cables are hardwired to the unit. The connector selection is what you'd expect to power a basic system build. There's a 20+4-pin main power, one 4+4-pin EPS12V (to power the CPU), and two PCIe 6+2-pin connectors. With the latter, the two PCIe 6+2-pin connectors are wired into a single cable, but Aerocool smartly provides six inches of extension between the first and second PCIe 6+2-pin connectors, so the connectors could be split among two midrange cards that are spaced apart inside a case. Of course, you could also connect both PCIe 6+2-pin connectors to a single high-end card.

To power the other devices and fans in your system, the VX-700 provides six SATA connectors, three Molex cables, and one floppy connector. We like that

Aerocool provides two SATA and one Molex connector on each peripheral power cable, because the mix of SATA and Molex connectors helps to avoid routing another long cable when you just require one more SATA or Molex connector.

The VX-700 includes electrical protections to ensure connected hardware won't be affected by power fluctuations. Aerocool builds in over-power, over-voltage, under-voltage, and short-circuit protections. In terms of efficiency, Aerocool rates the PSU for a peak efficiency of 81% at 50% load. When under 100% load, the VX-700's efficiency is 79%.

We tested the VX-700 in a system featuring Intel's Core i7-6700K and ZOTAC's GeForce GTX 780 AMP! Extreme Edition. To push the PSU under load, we simultaneously ran Prime 95's Small FFT test along with the Unigine Heaven 4.0 benchmark at the highest settings and a resolution of 2,560 x 1,600. The VX-700 had no problems handling these tests, and it delivered a maximum wattage of 379W at a power factor of 0.980. At slightly above 50% load, the power factor is what we'd expect.

We've spent a lot of time with Aerocool's cases and fans, but this is our first experience with an Aerocool PSU. The VX-700 stays within Aerocool's budget-friendly wheelhouse, yet it is capable of supporting midrange builds, assuming you're not using multiple high-end GPUs. The plain design also makes it a good choice for aesthetically-minded builders who want a PSU to blend in with a dark case. The VX-700 should be available in late September or early October. ■

BY NATHAN LAKE

VX-700

\$69.99

Aerocool

www.aerocool.us

Specs: Maximum wattage (continuous): 700W; 12V rails: 1 (54A); +5V max: 18A; +3.3V max: 22A; Efficiency rating (advertised): 81%; Fan: 120mm; Connectors: 1 x 20+4-pin ATX, 1 x 4+4-pin ATX/EPS12V, 2 x 6+2-pin PCIe, 6 x SATA, 3 x Molex, 1 x floppy; Warranty: 2 years

Test system specs: Processor: Intel Core i7-6700K; Motherboard: GIGABYTE GA-Z170X-GAMING G1; GPU: ZOTAC's GeForce GTX 780 AMP! Extreme Edition; Memory: 16GB Crucial Ballistix Sport DDR4-2400; Storage: Intel SSD 730 Series 240GB; OS: Windows 8.1 Enterprise (64-bit)

Skylake Lands In Chicago

GIGABYTE Unveils Its Z170 Boards

As we were putting the final touches on our August issue, GIGABYTE, Corsair, and Intel invited us out to Chicago for a one-day press event to give us a hands-on preview of all the goodies that we'd be seeing from GIGABYTE's Z170 motherboards, Intel's new Skylake processors and chipsets, and the slightly less new DDR4 memory.

The morning kicked off with a product deep-dive with GIGABYTE's new Global Marketing Director, Jonathan Geoffroy. He spoke at length about GIGABYTE's new Z170 chipset-based motherboards and the features that make them an ideal platform for the enthusiast looking to upgrade.

GIGABYTE is releasing numerous 100-series motherboards in three categories that should already be familiar to our readers. They all feature new heatsink designs, reinforced PCIe x16 slots, and familiar color schemes. The red, black, and white G1 Gaming Series is for people who use their computer primarily for gaming. The orange and black Overclocking Series boards are for the performance perfectionists among us. And the black and gold Ultra Durable Series offers a balanced mix of performance and durability features to appeal to professionals and users who tend to perform more varied computing tasks.

G1 GAMING

One of the first innovations we were treated to, and one that is featured on GIGABYTE's flagship Z170X-GAMING G1 motherboard, was the Intel USB 3.1 controller backed by a quartet of Gen 3 PCIe lanes. This unique chip supports bandwidth up to 32Gbps total, or up to 10Gbps per port. USB 3.1 is of course backward-compatible with USB



Intel and GIGABYTE recently took the wraps off Skylake and some new Z170 motherboards. GIGABYTE's Z170X-GAMING G1 is a flagship board that looks every bit the part.

2.0/3.0, and a handful of GIGABYTE's motherboards will come with both the familiar and ubiquitous USB Standard-A connector and the new USB Type-C connector, which is reversible and considerably more compact. Another GIGABYTE-exclusive feature is the USB

3.1 front bay accessory, available with select motherboards, which gives you a more convenient way to plug in your fancy new USB 3.1 devices.

The Z170 chipset lets the PCIe controller wear an M.2 hat, with access to the same four lanes described

Intel® USB 3.1 Controller PCIe Gen 3 x4* Other USB 3.1 Controller PCIe Gen 2 x2*	Up to 32 Gb/s* for 2 USB 3.1 Ports	Extreme
	Up to 10 Gb/s* for 2 USB 3.1 Ports	
	■ GIGABYTE USB 3.1 Design ■ Other USB 3.1 Design	<small>*Max. bandwidth allocated for the controller</small>

We suspect the inclusion of Intel's USB 3.1 controller will go over well with power users.

above for per-device bandwidths up to 32Gbps. And because there are two of these M.2 connectors on the GAMING G1, RAID becomes a very enticing option. This board supports both the PCIe and 2.5-inch versions of Intel's NVMe-capable 750 Series SSD, the latter of which utilizes the included M.2-to-U.2 mini-SAS card adapter.

The gamer-centric motherboard also comes with discrete-quality sound processing, courtesy of its quad-core Creative Sound Blaster ZxRi audio components. Features include Burr-Brown High-End 127dB DAC, support for 120 dB+ SNR headphone jack output, and the same high-end Nichicon fine gold and WIMA FKP2 audio capacitors typically found on audiophile-class equipment. In addition to the hardware's ability to produce richer bass and clearer high frequencies, Creative also lets you take greater control over your audio experience with its SBX Pro Studio software.

Overclocking Series

GIGABYTE's SOC (Super Overclock) motherboards are getting the Z170 treatment, as illustrated in the Z170X-SOC FORCE. Highlights of this board include three PCIe 3.0 x4 M.2 slots that split a 32Gbps pipeline and support a handful of RAID configurations. Another thing that caught our eye (also available on the Z170X-GAMING G1 board) is the G1/4 fittings that let you add the VRM heatsink to your custom liquid-cooling loop. The board also features plastic shields over the entire I/O side of the board and around the newly redesigned OC Touch buttons, which give

you an impressive amount of control over the CPU ratio, BCLK (Base Clock) ratio, BCLK steppings, PCIe slots, CMOS settings, and more without ever having to sift through BIOS screens.

Additionally, the Z170X-SOC FORCE features OC Connect USB ports that make it easier to apply BIOS updates and perform other USB-based tasks without having to reach over to the less-accessible I/O panel. The left side of the board also now sports an OC PEG connector for adding supplemental power to the PCIe slots. GIGABYTE bundles its OC Brace with this board, which gives overclockers the ability to install up to four graphics cards in an open bench without worrying about the PCIe slots snapping off. GIGABYTE's Q-Flash Plus port is a time-saving feature directed at power users that lets you update the

BIOS via USB without having a CPU or memory installed.

Ultra Durable

The Ultra Durable line of motherboards doesn't get the same attention regarding new exclusive features, but that's part of the point. These motherboards are designed to offer the best of all worlds, with features for gamers, casual overclockers, and general PC enthusiasts. Standout features you'll see on these boards include a dual-port Intel GbE LAN controller with support for Teaming, up to three SATA Express ports for up to 16Gbps data rates for compatible storage devices, and multi-GPU support for 2- and 3-way CrossFire and SLI configurations.

These boards, in addition to GIGABYTE's G1 GAMING and SOC boards,



GIGABYTE has a nifty Heroes Of The Storm tie-in for a handful of its motherboards.

all feature the firm's familiar Ultra Durable components, such as Audio Noise Guard PCB layer separation and discrete digital and analog grounds to reduce EMI, 10,000-hour solid-state black capacitors, and 15µ gold plating on the socket pins for more reliable conductivity. They also come with a handful of onboard buttons for overclocking, clearing the CMOS, debugging, and managing your BIOS mode.

Skylake Sneak Peak

Following the rundown of GIGABYTE's latest motherboards, Intel Desktop Chipset Business Operations and Roadmap Manager Eric Ingersoll gave us a brief introduction to the new 14nm Skylake K Series processors that launched on August 5th (but would not become available until August 14th). Intel is keeping many of the architectural

specifics under wraps until the Intel Developer Forum on August 18th, but we did glean a few notable facts.

The flagship Core i7-6700K (\$350 MSRP) features a 4GHz base clock, a 4.2GHz Turbo Boost clock, 8MB of Intel Smart Cache, Hyper-Threading support for processing up to eight threads at once, and a TDP of 91 watts. The more affordable Core i5-6600K (\$243 MSRP) lacks its sibling's Hyper-Threading and makes due with a 3.5GHz base frequency, a 3.9GHz Turbo Boost frequency, and 6MB of Intel Smart Cache. Both chips rely on Intel's new HD Graphics 530 engine, which sports 24 execution units, a 350MHz base clock, and a 1,150MHz dynamic clock. Both also drive as many as three displays, with the Core i7-6700K supporting resolutions up to 4,096 x 2,304 and the Core i5-6600K supporting up to 3,840 x 2,160.

As these are K Series processors, you can bet overclocking is a big part of the appeal of both 6th generation Core processors. Of course the unlocked multiplier is a big hit with us (and likely you), but Intel also adds much more granular clocking capabilities. Systems with either of these processors and a Z170-based motherboard no longer require PEG/DMI ratios, the PEG/DMI domain features an isolated 100MHz clock, and the BCLK has full fine-grain overclocking capabilities.

To help you capitalize on these features, GIGABYTE's motherboards feature a 4th generation International Rectifier digital controller and 3rd generation PowIRStage ICs, up to an impressive 22 phases. That's enough to ensure your components have all the clean, reliable power they need, whether you're pushing your system hard, or pushing it even harder to break some OC records.

DDR4 For All

Colin Brix, the Corsair Technical Marketing and PR Director (formerly with GIGABYTE) spoke about the firm's Hydro Series liquid coolers and how they make a great team with Intel's new K Series processors, which won't ship with CPU coolers of their own. He also talked about the DDR4 and DDR3L memory support on Z170 motherboards. Although the memory controller in Skylake is limited to dual-channel, the platform will benefit greatly from high-speed DDR4. By most early accounts, Skylake overclockers are seeing between 4.5GHz and 4.8GHz overclocks, and a liquid cooler is a must-have for anyone wanting to hit those numbers.

Fun At The Lake

Intel's CPU architectures have taken us from Bridges to Canyons and Wells, but the view from the Lake looks to be better than ever. In the coming weeks and months, *CPU* will be taking a much closer look at Skylake processors and numerous Z170 motherboards, so stay tuned. ■



Here's the Z170X-GAMING G1 showing us its mettle.



Make It Yours.



**"I WANT TO HAVE A PART IN
SHAPING VR FOR THE
BETTERMENT OF HUMANITY."**



Dilun Ho VR DEVELOPER

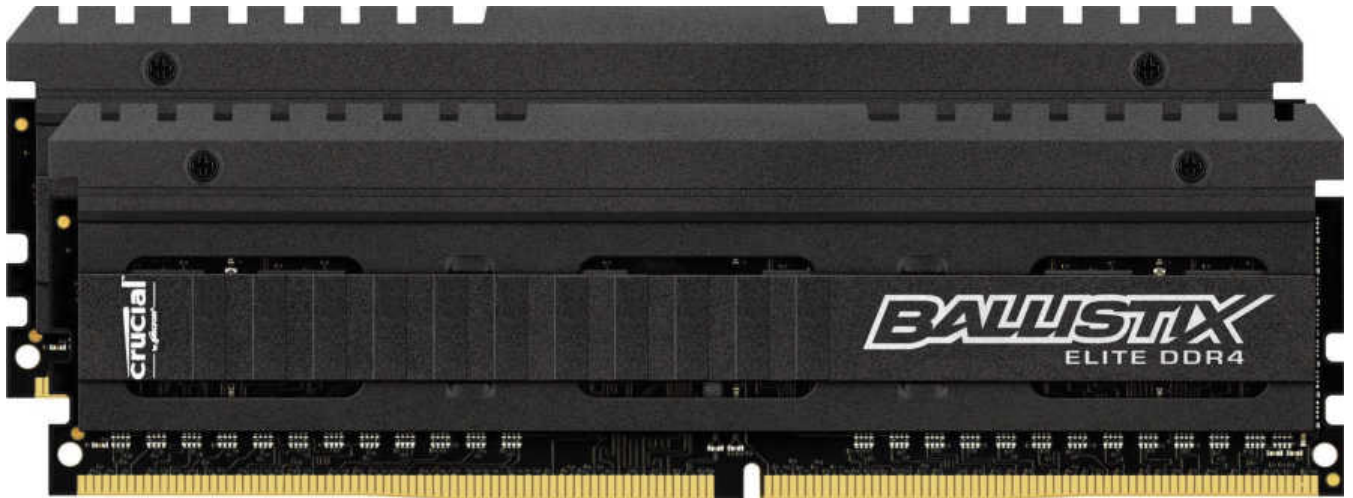
For as long as he could remember, Dilun wanted to escape the shackles of web development and become a game developer. The chance presented itself with his discovery of Virtual Reality. That's why he built his workstation with the **MasterCase Pro 5**. The flexibility of the **FreeForm™ Modular System** lets him customize, adjust, and upgrade his case to meet his needs, so he can tweak and improve the interactive environments he creates to share with future virtual adventurers.

Learn more about Dilun and his build at Coolermaster.com/Dilun

MasterCase 5 - Make of It What You Will.

Go Ballistix

Crucial DDR4 Lets Your Skylake System Fly High



Intel's recently released Skylake platform supports DDR4 memory, finally freeing you from the shackles of outdated DRAM, so why on earth would you settle for inferior modules? Crucial's Ballistix Elite DDR4 modules are among the best money can buy.

After months of anticipation, Intel's 6th Generation Core processors, code-named "Skylake," have arrived. Skylake chips represent a new level of desktop performance, which is certainly exciting. But what's really exciting is that these new processors extend DDR4 support to a much wider audience; no longer is the next generation of DRAM exclusive to Intel's family of HEDT processors.

Although the Skylake platform does support DDR3L, where's the fun in that? The time has come to ditch DDR3 (which is eight years old at this point, in case you need a reminder) and hitch your wagon to a younger, fresher, and faster memory technology. Because switching from DDR3 to DDR4 can yield impressive performance gains, picking the right kit is not a decision to make lightly. When choosing your new set of sticks, we recommend sticking with memory makers that have a proven track record of putting out high-quality products. One company that fits that bill is Crucial.

Flying under the company's Ballistix flag, Crucial's kits of enthusiast DDR4 are available to all power users, regardless of performance need or budget. The Elite, Tactical, and Sport lines are ready to take Skylake to new heights.

Ballistix Elite: My DDR4 Can Beat Up Your DDR4

If you demand nothing less than the pinnacle of performance, Crucial's Ballistix Elite DDR4 is the memory you need (and deserve). Representing the best the company has to offer, Crucial Ballistix Elite DDR4 cruises along at a cool 2,666MTps (mega transfers per second), and you can buy a dual-channel kit in either 8GB or 16GB. (And of course, as long as your motherboard has enough slots, you can always buy a 32GB kit [4 x 8GB] and load up on even more high-speed memory.) This memory is for any power user chasing the next record or higher overclock, but it's also

perfect for gamers running brutally demanding titles or prosumers who rely on gobs of ultra-fast memory to create exceptional content.

In addition to its top-notch performance and incredibly cool heat spreaders, Ballistix Elite DDR4 has a secret weapon: Crucial's M.O.D. utility. Short for Memory Overview Display, the Ballistix M.O.D. app gives you an inside look at your memory's vital signs, including SPD data and temperature. You can monitor the latter in real time, so extreme overclockers who need to know every component temperature at all times will delight that the Ballistix Elite DDR4 makes their job that much easier.

Ballistix Tactical: Up Your Game

The next weapon in Crucial's Ballistix arsenal is the Ballistix Tactical memory. Like the Ballistix Elite, Ballistix Tactical modules are clocked to offer a 2,666MTps data rate, so memory bandwidth should not be a problem.



Crucial Ballistix Tactical modules can handle just about any workload you throw at them, including modern games and media-editing applications.

Dual-channel kits of 8GB or 16GB are available, and a massive 32GB kit of four 8GB modules can be yours for the taking, too.

Ballistix Tactical memory is ideal for gamers who understand that good DRAM is plenty important for modern games. For anyone who regularly edits their media—whether that's photos, videos, music, or a combination of all three—Ballistix Tactical DDR4 definitely provides the performance needed to finish jobs faster.

PC builders will also dig the Ballistix Tactical's look. The aluminum alloy heat spreaders have a gunmetal gray finish, making them a sharp-looking addition to any system.

Ballistix Sport & Sport LT: Every Enthusiast Deserves DDR4

As we mentioned, Skylake opens the doors to DDR4 for virtually everyone. For mainstream Skylake rigs, Crucial's Ballistix Sport memory is more than up to the task. Operating at 2,400MTps, Ballistix Sport DDR4 memory is also energy-efficient, requiring a mere 1.2 volts to operate. (This is a trait shared with Ballistix Elite and Tactical DDR4, as well.) Whether you go with an 8GB, 16GB, or 32GB kit, Ballistix Sport memory is terrific for everyday PC use; finally, you can get the full multitasking experience of Windows 10. Casual gamers and those addicted to

indie games will find that a kit of Ballistix Sport works well.

Ballistix Sport and Sport LT modules have slightly different heat spreaders. Ballistix Sport memory has a simple, yet sleek design, consisting primarily of a solid gray color; its heat spreaders don't extend beyond the modules' PCB,

so the memory should be compatible with any desktop hardware configuration. Sport LT heat spreaders peek above the module PCB ever so slightly and feature what Crucial calls a "digital camo" design.

You Have Chosen . . . Wisely

As you consider which components to use for your Skylake build, we have no doubt you'll be faced with more than a few tough decisions. Crucial gives you plenty of options, as well, but perhaps the best thing about the company's Ballistix DDR4 kits is that any choice you make is a great one. ■



We challenge you to find a cooler kit of mainstream DDR4 than the Ballistix Sport LT. Crucial's Ballistix Sport DDR4 (not pictured) has a slightly shorter heat spreader and trades the Ballistix Sport LT's digital camo design for a solid gray color.

State-Of-The-Art Standards

OpenGL

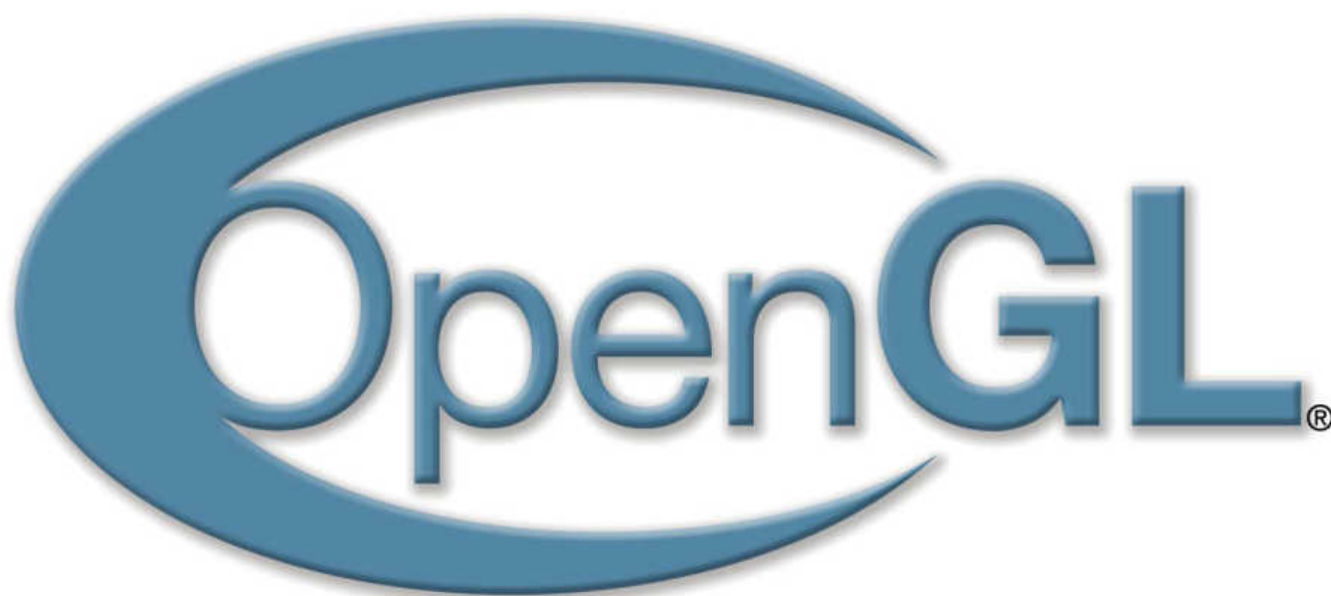
Remember the API wars of the late 1990s and early 2000s when Microsoft's Direct3D and early DirectX versions competed against variants of OpenGL? Microsoft's DirectX, of course, has been the de facto standard for years, yet something still stirs in the land of OpenGL. The Khronos Group (the industry consortium that took over the development of OpenGL) recently announced the Vulkan open standard API, which is designed to provide applications near direct control over GPU acceleration. Could we soon be witness to API Wars II? We'll examine the history of OpenGL and see what the future holds for open API standards.

SGI & OpenGL

Short for Open Graphics Library, OpenGL has long been designed as a multiplatform, cross-language API for hardware-accelerated graphics rendering. The open-source nature lets hardware and software developers customize the API for high-performance computing fields and applications, which have historically included CAD, flight simulation, scientific and information data analysis, and videogames. As previously mentioned, Microsoft's DirectX has been the primary area of focus of game developers over the last decade, but OpenGL is still vital for those running games on Linux and Mac operating systems.

OpenGL was officially released in 1992. SGI, which is now known as Silicon Graphics International but was Silicon Graphics, Inc. at the time, developed the standard. In 1992, SGI was acclaimed for its digital visual effects platform and technology. For example, SGI products were used to create the groundbreaking visuals in "Jurassic Park" and "Terminator 2: Judgment Day."

The initial API for OpenGL served as an open alternative to SGI's Iris GL, which was the proprietary graphics API on SGI workstations. On the whole, SGI viewed OpenGL 1.0 as a state machine that controls a set of specific drawing operations. For programmers, OpenGL 1.0 served as another way to



Officially released in 1992, OpenGL has a long history with PC graphics acceleration technology.

specify geometric objects and render those objects within the card's frame buffer. Within a typical program, OpenGL 1.0 starts with calls to open a window where the application will draw. The calls are made to allocate graphics language context, as well as to control the frame buffer.

In the early 1990s, most consumer graphics cards didn't support OpenGL, so it wasn't initially the most useful tool for game designers. In 1996, the OpenGL API found a strong advocate in id Software's John Carmack, who developed Quake for OpenGL and found that, at the time, it was a much better videogame API than Microsoft's Direct3D. Carmack and id went on to create GLQuake, which was a source port for Quake and Quake 2 that took advantage of the OpenGL API. GLQuake allowed for effects such as transparent water, reflective surfaces, and shadows.

In part due to Carmack and Quake's influence, graphics card companies began to support OpenGL via MiniGL drivers that allowed for better 3D acceleration. NVIDIA would add even more augmentations to OpenGL with register combiners. This was notable because the combiners took full advantage of NVIDIA's TNT hardware and let the GPU access, from any stage, the texture values and per-vertex colors.

Versions of OpenGL evolved along with new hardware advancements. OpenGL 1.1 was released in 1997, while OpenGL 1.2 (and 1.2.1) hit in 1998. Imaging subset was one of the most important features added to OpenGL 1.2 for image processing, as the subset included core capabilities for 3D texturing and level of detail controls.

When NVIDIA released its GeForce 256 (the card where NVIDIA coined the term "GPU") in 1999, OpenGL was able to take advantage of the card's distinctive T&L (transform & lighting) features, because the API had a dedicated T&L pipeline. Microsoft, by comparison, had to add T&L to support the DirectX standard with the release of DirectX 7.



Quake's engine used OpenGL to provide 3D hardware acceleration.

Fahrenheit

In 1997, SGI and Microsoft joined forces to "create a common, extensible architecture" under a project code-named "Fahrenheit." The undertaking was designed to bring together the consumer (DirectX) and professional (OpenGL) graphics APIs, so developers would only need to know one API for graphics and visualization applications. At the time, Ed McCracken, chairman and CEO of SGI, said, "Today, Silicon Graphics and Microsoft are defining a clear path for developers that enables both of us to expand the market for graphics."

The alliance would last only two years. Microsoft and SGI could not find common ground, and the entire project was abandoned with little to no functional code ever produced. Experts have speculated a variety of reasons for the failed marriage, and although a general lack of industry support was seen as the primary roadblock, there's never been a clear story about why the project failed. Microsoft, of course, continued work on its DirectX API, and when Windows 2000 was released, the OS was loaded with DirectX 7.

Progress Slows

At the turn of the century, the once prolific group of graphics AIB (add-in board) developers had started to dwindle. Microsoft had begun to work primarily with NVIDIA and ATI, and a new version of DirectX would often coincide with Team Green's and Team Red's newest GPUs. OpenGL, on the other hand, tacked on support with the updates that sometimes didn't appear until a year after the relevant hardware had been released. For example, OpenGL 1.3 wasn't released until 2001, almost three years after OpenGL 1.2.

Some have pointed towards the ARB (Architectural Review Board) as a major factor in the delay, as new features required approval from a standards committee. It didn't help that many members of the ARB were rival companies, and intellectual property threats in particular were seen as key frustrations. In some cases, the biggest advances were made in OpenGL extensions, rather than updating the standard as a whole. With each company promoting its own technology, OpenGL began to fall behind.



If you want to learn more about the OpenGL API, visit opengl.org.

By 2002, Microsoft had created DirectX 9 and a high-level shading language (Shader Model 2.0) to support GPU improvements for pixel shading, vertex shading, and overall visual quality. OpenGL, at the time, wasn't able to take full advantage of dedicated hardware shader pipelines. To help catch up, the ARB would work with 3DLABS to spearhead the development of OpenGL 2.0 and support for shading language. OpenGL 2.0 wasn't released until 2004, and not long after 3DLABS exited the graphics card business altogether, stopping development in 2006.

Khronos Group Takes Control

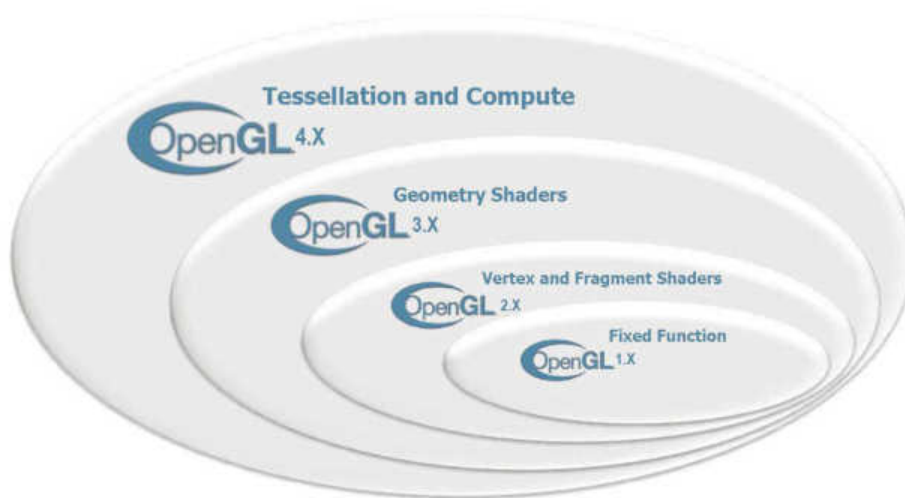
At SIGGRAPH 2006, the OpenGL ARB passed governance

of OpenGL's API over to the Khronos Group. One of the first acts of the Khronos Group was to establish an OpenGL Working Group that would be responsible for controlling and evolving the OpenGL

standard. At the time, ARB secretary Jon Leech said, "The evolution of the OpenGL API and the membership of the ARB have reflected the changes in the graphics industry over the years as the use of 3D graphics moved from high-end workstations and simulators to PCs and mobile laptops, thanks to a new generation of consumer-oriented companies, such as Apple, ATI, and NVIDIA. We have decided to move the OpenGL specification into Khronos to ensure the future health of OpenGL in all its forms."

With a joint road map, the OpenGL train was no longer off the tracks. But by this time, OpenGL API support was not nearly as important to developers as Microsoft's DirectX, and the standard was years behind. By 2008, the Khronos Group was able to deliver OpenGL 3.0. This release marked a major revision of the API, as it included a new version of the OpenGL shading language (GLSL 1.3) and a set of OpenGL extensions that would bring the new functionality to older hardware. AMD, Intel, and NVIDIA all made contributions to the design of OpenGL 3.0 and would immediately support it within the respective product lineups.

OpenGL for Each Hardware Generation



© Copyright Khronos Group, 2015 - Page 8

OpenGL has evolved with the latest GPU capabilities.



From software to silicon, the Khronos Group consists of members from every computing area.

The Khronos Group also focused on defining how the OpenGL specification would evolve and retire obsolete functions. In the press release announcing OpenGL 3.0, the Khronos Group stated, “The new OpenGL API supports the future creation of profiles to enable products to support specific market needs while not burdening every implementation with unnecessary costs. To avoid fragmentation, the core OpenGL specification will contain all defined functionality in an architecturally coherent whole, with profiles tightly specifying segment-relevant subsets.”

Barthold Lichtenbelt, chair of the OpenGL working group at Khronos, said, “OpenGL 3.0 sets the stage for a revolution to come. We now have the roadmap machinery and momentum in place to rapidly and reliably develop OpenGL and are working closely with OpenCL to ensure that OpenGL plays a pivotal role in the ongoing revolution in programmable visual computing.”

In March of 2009, the Khronos Group released OpenGL 3.1, which had additional

shading language updates and improved programmability that would allow for more efficient development of supporting software. “The rapid nine-month development of OpenGL 3.1 demonstrates the schedule-driven approach to the standard that is enabling and inspiring cutting-edge, cross-platform GPU functionality,” Lichtenbelt said. “OpenGL 3.1 answers the requests from the developer community to streamline and modernize the OpenGL API.”

OpenGL 4.0 landed one year later. The 4.0 update introduced shader stages that let the GPU offload tessellation from the CPU, as well as the ability to use per-sample fragment shaders and programmable fragment shader input positions. The greater flexibility helped to increase rendering quality and antialiasing. At the same time, Khronos introduced OpenGL 3.3 and a set of ARB extensions, which brought many of OpenGL 4.0’s new features to older OpenGL 3.0 cards.

Subsequent releases of OpenGL have rolled out on a fairly consistent basis. For

example, OpenGL 4.2 was announced in 2011, OpenGL 4.3 in 2012, OpenGL 4.4 in 2013, and OpenGL 4.5 in 2014. With the latter, the Khronos Group introduced core functionality for DSA (Direct State Access) that lets developers set and query the properties of objects, which could be textures, shader programs, and frame buffers, among others, without binding the object. This way, developers using or designing middleware won’t need to activate and undo bindings. DSA-like functionality has long been a part of Direct3D. For easier porting between OpenGL and Direct3D, OpenGL 4.5 offers a DX11 emulation capability.

Vulkan

With OpenGL brought up to speed with many of the most critical graphics acceleration techniques and technologies, the Khronos Group set its sights on something new. Vulkan is a ground-up design that removes much of the complex driver overhead that can slow down performance. Developers call this a low-level



The open-source Vulkan API is the Khronos Group's latest brainchild. Billed as a low-level API, Vulkan helps developers to get closer to bare metal for low latency among commands.

or low-overhead API, because they have a more direct path of control over the GPU. For example, most OpenGL drivers must include memory and error management, as well as shading language compilers and sources. Because the driver does a lot of work, it can impact performance.

On the Vulkan API, the Khronos Group starts by giving developers more explicit access. The application will now be in charge of memory allocation and thread management when generating command buffers, for example. Vulkan will mean more work for developers, but the low-level API is also more flexible. "As much of the design of Vulkan is being driven by the games engine vendors, we expect to see many AAA games engines running very efficiently across multiple platforms using Vulkan," says Neil Trevett, president of the Khronos Group. "Many non-gaming applications, such as VR and CAD design, will also benefit from Vulkan's efficient and predictable performance."

The Khronos Group indicates the Vulkan could also work on mobile devices, as well as game consoles and vehicles. Google, for instance, recently announced that it will release Vulkan for Android. The move to Vulkan should be natural for mobile app developers, as many use OpenGL. "OpenGL ships on every smartphone including Android and iOS, Windows XP to Windows 10, Mac, and Linux," says Trevett. "Many mobile developers first write their app on a desktop machine and then take to code to mobile devices."

Vulkan won't be finalized until later this year, so we don't have many details on the specifics. We do know that the Khronos Group plans to use its SPIR-V (Standard Portable Intermediate Representation) language to provide native support for shader and kernel features. It eliminates the need for a built-in high-level language source compiler by allowing the high-level language front-end to provide Vulkan or OpenCL drivers with a standardized program. SPIR-V also lets developers use SPI binaries, so the code can work with discrete GPUs, onboard processor graphics, and SoCs.

Vulkan & Industry Support

In the past, the lack of reliable support from industry partners often delayed or derailed OpenGL development efforts. With Vulkan, the Khronos Group has partnered with today's biggest hardware developers, including Intel, AMD, NVIDIA, ARM, Qualcomm, and Imagination Technologies, as well as software developers, such as Blizzard, Epic Games, Valve, and TransGaming. Jem Davies, ARM vice president of technology, media processing group says, "Vulkan is a big step forward in enabling our ecosystem of developers to unleash the capabilities of the latest ARM GPU technology."

The Vulkan API also received a boost from AMD's Mantle initiative, as AMD allowed the Khronos Group to use parts of Mantle to serve as Vulkan's foundation. In

its brief existence, Mantle found favor with a few game developers, such as EA with Battlefield Hardline and Cloud Imperium Games' Star Citizen.

In a blog post about the transition, Robert Hallock, AMD head of global technical marketing, says, "Mantle has seen acclaim for many improvements in gaming and game development: higher frame rates, reduced rendering latency, reduced GPU power consumption, better use of multicore CPUs, and re-pioneering new features like split-frame rendering. Vulkan combines and extensively iterates on these characteristics as one new and uniquely powerful graphics API."

The Future With Khronos

"Khronos is fully committed to supporting and developing all of its 3D APIs as long as developers use them," says Trevett. "Vulkan is the newest member of the family, and will be great for many developers, but OpenGL and OpenGL ES are not going away—and are being actively evolved in parallel with Vulkan—as the release of OpenGL ES 3.2 and OpenGL extensions at SIGGRAPH [2015] demonstrates."

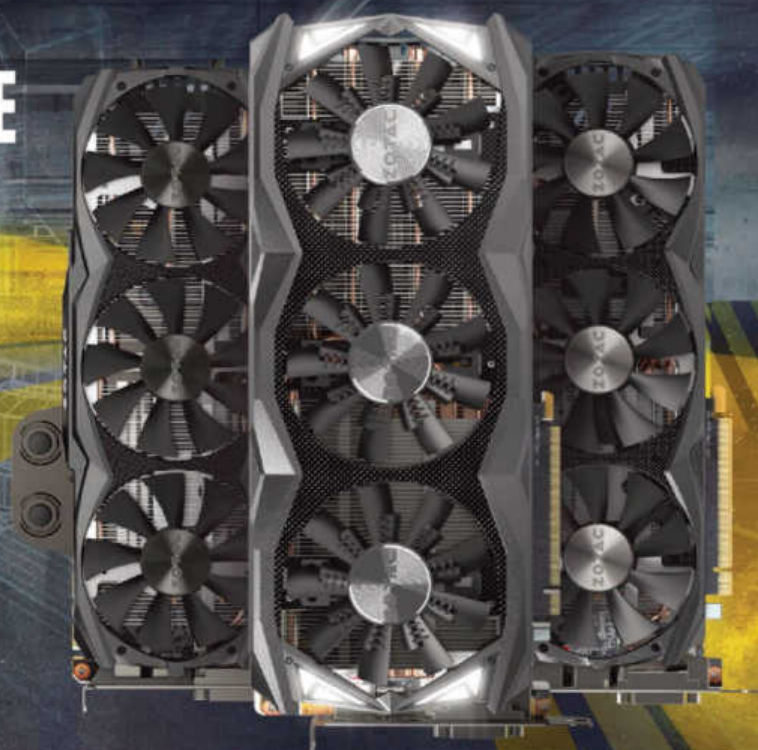
Vulkan is also designed to port easily across platforms and hardware, so the open API should be a boon to developers that want consistent performance for games that run on all different devices. Whatever comes along, the future of open-source graphics acceleration looks much brighter than its recent history. ■

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RevoluTtion

The winner of the Case Mod category of this year's QuakeCon mod contest was Marc "marcam923" Molella's RevoluTtion, and it's a long time coming, apparently.

"This is a mod I have been thinking about for roughly six years," Molella says. "I wanted to create something that showed moving components outside the computer case (such as the working gear mechanism on the right side panel and the fans visible through the front) to coincide with electronic circuitry and the transfer of information constantly moving within, but that is not visible."

"Plus, I used copper that I hand-polished, which in my thought process tied in to the industrial revolution, where these metals began being used more widely, as well as machines being implements, and the computer is a machine. Instead of just naming the machine 'Revolution,' I added the extra T to thank Thermaltake, the creator of the Suppressor F51, and for allowing me to bring this vision to reality."

Molella says his inspiration when modding comes from many sources: "Like most other artists or creative minds, I draw inspiration from almost everything around me: the works of others, nature, and the people that daily touch my life. I use that inspiration to take one portion of that experience, and create from it a vision. Before I begin a case mod, I see the finished product in my mind, and from that point it is simple—just make that vision a reality."

Molella says he can't even begin to estimate the number of hours he spent working on RevoluTtion, but that the work was completed over a period of roughly three months.



The Copper

"I created the front panel, power supply shroud, and the Tt logo on the gear mechanism on the back side panel from copper sheet," Molella says. "I hand-polished it to a mirror shine, cut the components to what I wanted them to be, and then treated them so they would not tarnish and would stay in this condition."

The Paint

"I spray-painted the case's exterior with Firemist Orange Metallic, which is why in some of the pictures, certain portions look darker than others. It takes on different shades from different angles and has the amazing metallic effect. I really wanted to draw a contrast, which is why a case that started its life almost completely black in color, is now orange and white."

The Details

"I truly wanted to build a piece of art; something that would make you have to take a second and third look to notice all the detail," says Molella. "Then, after the third look, there might be things you still wouldn't notice, possibly unless someone pointed it out, such as the customized front door opening, revealing another custom panel inside, or the gears on the back side panel. Everything was layered. I did this because I wanted to bring back the definition of why I started modding . . . why a lot of people started modding. It's not just about the paint job or watercooling, it's about building something truly unique that fits your character or personality."

Molella says his initial forays into the world of modding were for more practical purposes: "I began modding cases to allow for better air flow, because I was overclocking my components but couldn't afford high-end computer cases. Once I began doing this, I started wanting to make the case look aesthetically

pleasing, as well, so it became a mesh of the two worlds, overclocking and aesthetics."

The rotating gears on the right-side panel is a custom clockwork assembly painted to match the build; Molella attached his hand-cut copper Thermaltake logo, which is mounted on a piece of acrylic to create the appearance that it's floating.

He also trimmed out the case's interior by adjusting the size of the motherboard tray so that it stays out of sight and adding custom white acrylic pieces as needed to make the copper PSU cover and the orange coolant pop. He then sleeved all of his power cables in paracord, bent 16mm rigid tubing for his cooling loop, and custom-mixed silver Mayhems Aurora 2 coolant with orange dye to make it match his paint job.

RevoluTtion is a Thermaltake Suppressor F51, an Intel Core i7-5820K mounted on a GIGABYTE X99-SOC Champion, 16GB of G.Skill Ripjaws DDR4-3000 memory, an MSI GTX 970 GAMING 4G graphics card, a Thermaltake Toughpower DPS 850W power supply, a G.Skill Phoenix III 120GB SSD, and a Western Digital Black 1TB hard drive. His cooling subsystem consists of Thermaltake 16mm PETG rigid tubing, a Thermaltake Pacific W2 CPU block, a Thermaltake Pacific PR22-D5 pump/reservoir combo unit, a Hardware Labs Black Ice GTX 360 radiator, a Bitspower GTX 970 block, and seven Thermaltake Riing case fans.

The End

Molella says that he brought this mod to QuakeCon, then participated in the 24-hour live modding event at the show and is still putting finishing touches on that project. All of this hasn't stopped him from thinking ahead, though, and he says he already has ideas for his next six mods.

Perhaps one of them should be called "Prolific." ■



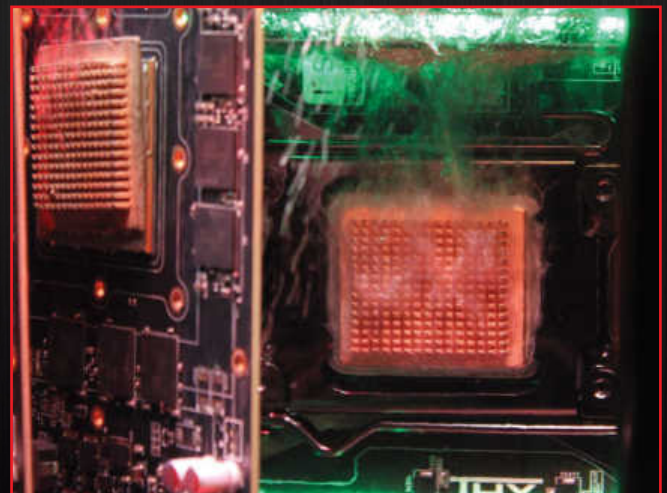
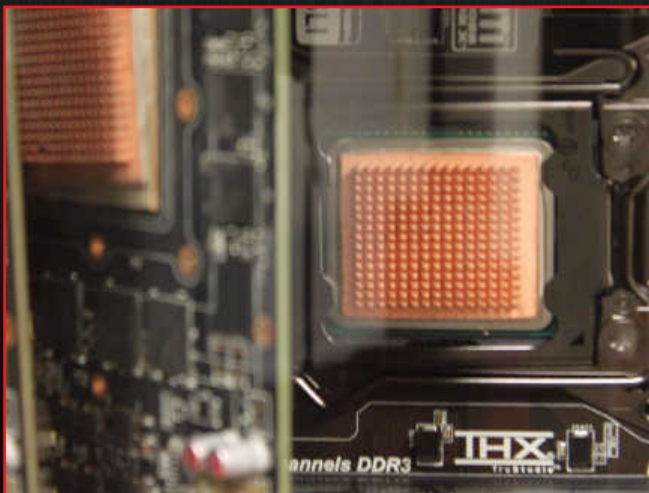
VaporPhaze 360

This year at QuakeCon, Zac Glander won the Scratch Build category of the case mod contest with a mod that is not only interesting to look at, but is also an extremely impressive bit of engineering. Glander named his mod “VaporPhaze 360” because it uses a very unique form of cooling, and because the case gives you a full 360-degree view of the components inside.

“I have been inspired by this technology since 2000, when I learned about liquid-immersion cooling,” Glander says. “The concept had been rattling around in my head for 10 years before I decided to start bringing those thoughts to life in 2010. From a very young age, I have had a knack for building computers. I was always wanting to know why and how they worked. At age 12, I was given my first hand-me-down computer, a 486 that I took apart just to put back together. From that point on, I have been building, repairing, and maintaining computer systems of all types. I now run my own IT services business, so as you can see, I have always had a passion for computers and all that they entail.”

Glander says he mods anywhere he can find space, including at home, at his office, and in friends’ shops. Once the ideas that led to VaporPhaze 360 began to fully jell in his mind, he spent approximately a year and a half designing and building the system as time allowed. He says the rig turned out exactly the way he imagined it, but not without plenty of revisions and tinkering.

“I built my first system to prove that the concept could actually be made to work, and to prove to myself that I could build a working system,” Glander says. “The system is not a mod, so to speak, as it has never been done on this level. True enough,



I used off-the-shelf hardware, but the rest of the computer was possible only through imagination. Thank god for computer-aided drafting!"

Science

"The system in general proves that liquid-immersion technology is relevant and a viable solution as an alternative to direct air, or any of other form of cooling," says Glander. "I have always been a stickler for a neat computer to allow for better air flow, thus making the system perform optimally. So, to get the most cooling possible, I decided to put the computer directly into 3M Novec 7000, which phase-changes at the low temperature of 34 degrees Celsius, meaning that the fluid changes from a liquid to a gas.

"During the phase change, heat energy gets transferred away from the hardware into its gas phase, where it is condensed back into a liquid in the radiator, in a closed-loop cycle. One of the best analogies that comes to mind is when you have a cut and you use rubbing alcohol to clean it. When you blow on the cut, the alcohol goes from a liquid on your skin to a gas, which makes your skin feel cold. I am able to use this exact effect that you can feel to cool computer equipment. Using this technology also allows me to cool the entire hardware package using only one 200mm fan drawing air through the radiator."

Glander says the process is not without its charms, and it has practical applications, too. "The bubbles are one of the more aesthetic effects in the system; this is the fluid actually boiling, just like a pot of water on the stove, only at a lower temperature," he says. "This system does fill a particular need in terms of being proof of concept, to be applied to servers in the near future. A producible gaming model is also in the works, which fulfills the extreme computing needs of gamers."

Design

Glander custom-designed the radiator where the magic happens, and says it's the world's first cylindrical radiator with vertical tubes that he's aware of. He also custom designed the cylindrical glass container that makes up the body of the case. It was built on a mandrel at 5mm thick and is guaranteed to withstand 50psi of internal pressure. The support structure inside consists fully of laser-cut aluminum with tolerances in the .0001 range.

Glander hand-tapped every screw hole in the build and did the finish work for the entire structure using a Bridgeport milling machine from the 1930s.

"The devices that look like small heatsinks on the components are specially designed boiling enhancement units," Glander says. "They are heatsinks with a proprietary nano-copper coating that makes the phase change occur in more places on the surface of the units."

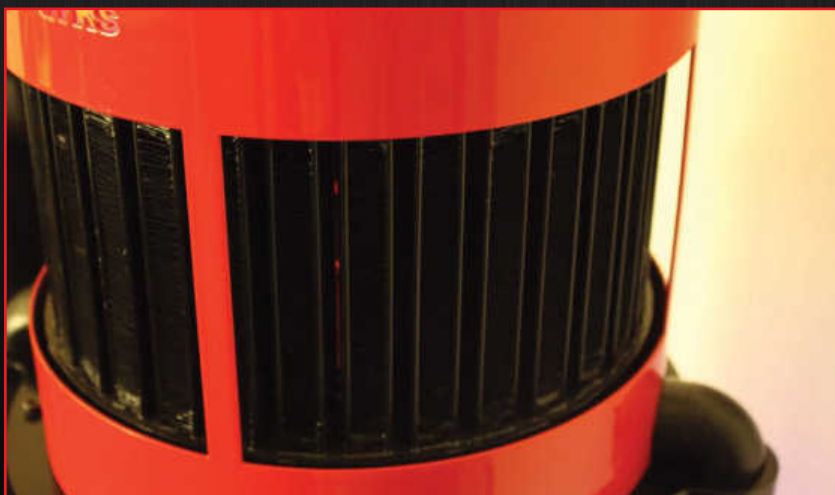
The rig's lighting is brought to you by about 500 LEDs of various colors.

Tech

In addition to its sophisticated housing, VaporPhase 360 is an Intel Core i7-3930K, an ASRock X79 Extreme4-M motherboard, 16GB of Crucial Ballistix Tactical Tracer memory, dual ZOTAC GTX 680 graphics cards in SLI, a SeaSonic X-Series 1250-watt power supply, two Crucial M4 128GB SSDs in RAID 0, and of course the aforementioned single 200mm Cooler Master LED fan.

Glander says his next rig will be even more powerful, with dual Xeon 2690 v2 CPUs, 64GB of RAM, and an NVIDIA TITAN Z graphics card. You can probably guess how he intends to keep all of this gear cool.

"All of this will be in my newly designed liquid immersion system," Glander says. ■



Peace, Love & Rockets

Adam “DOHCDragon” Owen is an old hand at winning the QuakeCon mod contest, although the last two times he won (not a typo), he bested the competition in the Scratch Build category. For QuakeCon 2015, Owen decided to mix things up a bit and enter the Bethesda/id Software category, and as you can see that worked out pretty well for him.

“I have made a goal every year to build a computer for QuakeCon,” Owen says. “This year being the 20th year, I wanted to do something that celebrated the event. Every year, the best description I see for QuakeCon is ‘A weekend of peace, love, and rockets.’ This case was designed to celebrate both the 20 years of QuakeCon and the 10 years that I have been attending. It is going to become my home server, and will sit on a pedestal next to my 3D printer in my man cave. It will serve as a reminder of all the good times I have had at the event, and as a symbol of what has been and what is to come.”

You might remember Owen’s 3D printer—or at least its handiwork—from the 2014 QuakeCon mod contest, in which Owen stormed the field with his operational WWII Tiger tank PC. And that’s not the only connection this mod has to QuakeCon’s past.

In The Beginning

Owen won the Cooler Master HAF XB that is Peace, Love & Rockets’ foundation as part of his prize package for winning the Scratch Build category of the 2013 QuakeCon case mod contest. As you can see, the left, top, and right panels each have a unique construction that represents part of the mod’s name (and, of course, the QuakeCon logo itself is proudly displayed on the front panel).



The original plan also included dry ice, but Owen says he had to scrap that idea after doing a 1:1 scale mockup and test. Then he began to work on his side panel designs in SketchUp.

"The only part that changed dramatically was love," he says. "The original design didn't look enough like a heart, so I scratched it and redesigned it. Once it was all designed in SketchUp, it pretty much came out exactly as designed. I believe the original design had room to grow, and the final work was better than I had imagined."

Can We Build It?

Owen removed all of the rivets from the HAF XB, then masked the outer surfaces of the case, along with select parts of the inside. He painted the case's interior white, and then went to work on each of the outer surfaces in turn.

Peace. "I cut a hole in the right side of the case and inserted a plasma shield," says Owen. "I added a ground strap to the side of the case to prevent people from getting shocked, then I 3D-printed a holder and covers to make the shield look like the peace sign. After I got all this done, the electronics that came with the plasma driver stopped working. I was able to purchase a \$20 plasma ball from Walmart and use its internal electronics to fix my plasma plate. Then I custom-built a white cover to house the new electronics and painted an orange Q on the back to go along with the theme of the case."

Love. "I replaced the top of the HAF XB with a piece of Plexiglas. I masked off the windows and painted the edges black to match the case, then cut a hole in the center of it for the 140mm

fan that I use to power the heart. The gears I borrowed from the 3D artwork I used in the 3D Printed Tiger Tank from last year; I wanted to show people how complex and yet functional the 3D printer can be. Next, I engraved '2015' on both sides of the heart. The top gear goes around once for every 50 times the fan spins all the way around."

Rockets. "I wanted to use something from Quake in the build, so I took the 2D rocket image from Quake and converted it into a 3D rocket. It is lit with orange and white LEDs. The entire fixture mounts to the outside of the case."

The Finishing Touch

Owen made the QuakeCon logo on the front panel with—you guessed it—his 3D printer. He then built a custom shroud for his video card that bears the message, "20 Years Of," along with symbols for Peace, Love, and Rockets.

In addition to the HAF XB, this mod contains an Intel Core i7-3960X, an ASUS SABERTOOTH X79 motherboard, 32GB of G.Skill DDR3-2400, an EVGA GeForce GTX 980, a Cooler Master Silent Pro Hybrid 1300W PSU, three OCZ Revo 3 240GB PCIe SSDs, a 3TB Western Digital Black hard drive, and a custom cooling loop and "miscellaneous fans."

Owen says he's already begun work on his mod for QuakeCon 2016, but like many master craftsmen, he's not ready to give up many details yet. He says he plans to start a work log on Modders-Inc.com, but not until "early November."

We'll be watching, Adam! ■



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The Best Of Bethesda's Breathtaking Show QuakeCon 2015

With new details and demos of Fallout 4, DOOM's multiplayer mode, and Elder Scrolls online, the 2015 edition (and 20th anniversary) of QuakeCon was certainly memorable for attendees. And while we're always excited to hear news from Bethesda, what really makes QuakeCon special are the mods in the BYOC. There were over 30 entries in the Modders-Inc.com U.S. Case Modding Championship, and we were given the opportunity to help judge the event. Prizes were awarded to the top three finalists in the Case Mod, Scratch Build, and Bethesda/ID categories, including \$500 from *Computer Power User* to the top mod in each category.



Attendees at QuakeCon 2015 were given a chance to play around in DOOM's new multiplayer mode.



A huge statue of a fearsome character from id Software's DOOM was available for some fun photo opportunities.



System build winner Richard San Martin (sitting in center) won the QuakeCon Battle Box we put together for the show.

At QuakeCon, it's always tough to pick a winning mod, and if you've checked out this month's special six-page "Mad Reader Mod" feature, you know how much effort and detail was required to earn first place. On the following pages, you'll be able to see the excellent work from the contestants who placed 2nd and 3rd in the respective categories. We promise you won't be disappointed.

Scratch Category

2nd Place

TF2 Sentry Gun / Michael Kraft

Michael Kraft is a big fan of Team Fortress 2, and his replica sentry gun was one of the best overall mods we saw at QuakeCon. The process of building the TF2 Sentry Gun was much more involved than hitting some metal with a wrench, as Kraft had to 3D model, print, hand-finish, and assemble around 80 pieces for this scratch build. The turret's main body alone took around five weeks to print on his Makergear M2. Kraft also designed the TF2 Sentry Gun with pan-and-tilt functionality (up to 180-degree yaw and 40-degree pitch). The movement turned out to be a big challenge, because the head of the sentry is large, heavy, and naturally unbalanced. Kraft used a series of springs and gear motors to balance the motion, which he can control via the embedded PC. The TF2 Sentry Gun cost under \$500 to build, including the raw materials and PC parts, yet it can still run TF2 at the highest settings. This mod is one sentry gun you'll want to position out in the open where everyone can see it.



TF2 Sentry Gun is shown under construction at far left. The completed scratch build, all dressed up and ready for battle, is shown at the immediate left.

3rd Place

Unlicensed Nuclear Accelerator / Mike Walt

A few years ago, Mike Walt was thinking how much easier it'd be to wear his computer into QuakeCon rather than lugging a full tower to the event. And because Ghostbusters is one of Walt's favorite movies, creating the Unlicensed Nuclear Accelerator was the obvious solution. The lifesize proton pack straps on just like the prop in the film, and it even features a detachable neutrino wand that will replicate the zapping sound effect. The Unlicensed Nuclear Accelerator's shell alone required six months of work, as Walt had to fill, sand, paint, and mount the fiberglass shell, as well as prep it for storing an entire gaming PC. Walt also had to create his own GPU shroud that was separate from the motherboard, which he tied into the shell by adding the Unlicensed Nuclear Accelerator title, as well as the Ghostbuster and QuakeCon logo. Once complete, the entire prop (with functional PC) ended up at only 30 pounds, so it was easy to carry around. Maybe most importantly, Walt remembered not to cross the streams.



Case Category

2nd Place

Purple Drank / Robert VanOrman & Matias Gonzales

When brainstorming case mod ideas, Robert VanOrman and Matias Gonzales noticed that almost no one uses the color purple. And boy, the internals of this case are purple (with a little white to pop the purple look). VanOrman and Gonzales designed and painted acrylic covers for the PSU, cooling loop pumps, and 5.25-inch drive bay, as well as the GPU backplate. The acrylic covers feature a logo designed by the duo, as well as the words “Purple” and “Drank” to showcase the mod’s title. Dual cooling loops (a purple one for the CPU and a white one for the GPUs) crisscross each other and further complement the color theme. You’ll also find custom sleeved purple and white power cables, which the builders hand stitched with waxed cotton cord. Two LED strips in the side panel top and bottom, as well as a third LED strip inside the case, ensure all the details are visible. On the front panel, they added a custom purple bezel that holds an LCD for a Raspberry Pi 2. VanOrman and Gonzales scripted an interface for the PWM fan controller, system lighting, and a launcher to serve as a game emulator for Genesis and SNES titles. It was only the second mod this pair has ever done, and we’re looking forward to seeing more of their excellent work.



Purple Drank makes the most of its purple and white color scheme. Below you can see some of the detailed custom sleeving work that went into this case.



3rd Place

Cosmos Tribute / Garrison Novak

Garrison Novak used his Cooler Master Cosmos S case for six years, and when he downsized to the Cosmos SE, he wanted to incorporate something from his original case. Novak molded the top of his old Cosmos S to fit into the front panel of the smaller Cosmos SE rig. Next, he disassembled the panels and drive storage mounts to create custom paneling, and he formed front and top panels using short strand fiberglass auto body filler. He replaced the original black coating with two layers of powder coating—a white coat followed by a clear coat with blue metallic flakes. Novak also gutted the inside to make room for an E-ATX motherboard, three-way SLI, and performance liquid cooling. The motherboard tray is upside down and there’s a four-drive SSD panel, which hides liquid-cooling components and cabling. The GPU blocks and CPU block boast their own independent lighting to match the blue and white color scheme.



Bethesda/id Software Category

2nd Place

QuakeCon 2K15 / Matt Brayton

Matt Brayton has been attending and enjoying QuakeCon for a number of years, and he wanted to create a simple, clean build as a homage to the event. Brayton hand-cut the iconic QuakeCon “Q” into the front panel and then smoothed it with a file. The logo and case internals glow brightly in the dark, and the case certainly stood out in the dark confines of the BYOC. Brayton used an RGB LED, so he could change the internal color scheme. At QuakeCon, the rig was lit up in orange, which harmonizes the case’s orange liquid coolant, rear and top exhaust fans, rear I/O shields, and the NZXT faceplate on the PSU shroud. On the stock NZXT H440, the rear I/O shields and NZXT faceplate were originally black, and Brayton found an orange color that perfectly matched liquid coolant. On the exterior, the black accent lines were also replaced with the same orange. The end result is a perfect mix of white and orange throughout the build.



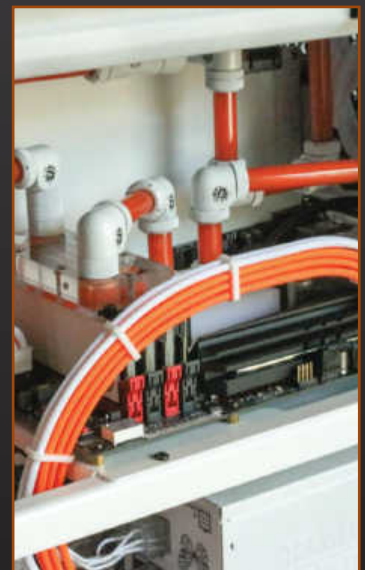
The bright logo on the front of Matt Brayton's QuakeCon 2K15 build shone like a beacon in the dark BYOC area.



3rd Place

QuakeCon 2015 / Layne Zerangue

Layne Zerangue's QuakeCon 2015 mod celebrates the 20th anniversary of the event with an exceptionally crisp white and orange color theme. Zerangue cut all of the cables to fit and used strategically placed cable combs to bundle them together, artfully blending the orange and white sleeves. The cables running to the motherboard arc in a smooth curve, which nicely contrasts with the straight hard tubing throughout the build. Zerangue spent hours shaving off millimeters from the hard tubing to ensure that all the hard tubing was perfectly straight. The orange and white theme is well executed throughout the custom loop, as well, with orange liquid passing through the clear hard tubing and white fittings. The rig almost didn't make the trip, though, because Zerangue's motherboard died and he had to bring the whole disassembled system to Dallas and rebuild the QuakeCon 2015 rig in his hotel room. We love it when modders are able to pull through in the clutch. ■



Hooked On A Feeling

KOR-FX Gaming Vest Puts Your Body Into The Action

For years—decades, really—we’ve relied on primarily two senses to absorb and experience our favorite videogames in all their glory. We see them and we hear them, simple as that. Sure, countless technologies intended to more fully immerse gamers in their games have come along. Some, such as 3D gaming, have gone, while others, such as multichannel surround sound, are here to stay. The fate of others, such as Oculus and its VR competition, remains to be seen. What all of these have in common, though, is that they give our eyes something different to see or our ears something different to hear.

Maybe it’s time to give another one of the five senses some love. Of course, we can reasonably remove two of those senses, unless smelling a *Last of Us* Infected or tasting a sample of *World of Warcraft*’s Carrion Surprise seems appealing to you. That leaves us with touch, which, in the context of gaming, is frequently referred to as haptics.

Haptic feedback, which delivers various physical sensations to the body, is hardly new to the gaming scene. Videogame controllers have included various implementations for nearly two decades—who remembers the Nintendo 64’s Rumble Pak? Joysticks with force feedback were popular among flight sim enthusiasts and other aviation games. Peripherals and accessories that use haptic feedback to make games more immersive are well-established.

Still, there’s plenty of room for innovation, a fact that Massachusetts-based Immerz knows well. The company’s KOR-FX gaming vest, which launched last year, is designed to take haptic feedback to new, more realistic, heights. The KOR-FX vest takes in-game positional audio of all kinds and translates it into haptic feedback that will shake you to your core, almost literally. When a grenade explodes to your right, the KOR-FX rocks your body



The result of five years of intense R&D, Immerz’s KOR-FX gaming vest is designed to let gamers feel the action like never before. The company is pioneering the field of acoustohaptic feedback.

accordingly. When a speedboat roars up to the docks to help you make your getaway, the KOR-FX delivers the physical sensation to let you know it’s here.

Make no mistake, though—the KOR-FX is way more than a rumble pack you wear on your chest. The latter rely on small spinning motors to make their vibrations, while the KOR-FX’s 4DFX technology uses a pair of specially designed transducers to produce haptic feedback that is in a class of its own. This is a harness that can harness your game’s sounds like you’ve never before experienced.

Immersion Through Science

Founder and CTO Shahriar Afshar relied on the principles of neuroscience in order to

engineer a product that would shake up the gaming world.

“We use the human brain as the main hardware, which our electronics merely trigger to project tactile/emotional reality,” Afshar says. “We achieve this by activating the limbic system in the brain by means of concurrent audio and tactile feedback, as well as visual clues that help cement the experience as highly immersive. The end result is a physical presence that none of the preexisting technologies can deliver.”

According to Afshar, the KOR-FX vest turns the wearer’s chest into an echo chamber that actually amplifies the vest’s directional tactile feedback, which it extracts from in-game audio. Specifically, proprietary algorithms use a game’s sounds

to create haptic information. The vest's transducers vibrate in such a way that mimics the naturally occurring vibrations that take place in the chest as a response to loud noises or speech. The brain then interprets the vibrations that the KOR-FX generates as the real thing.

"In this manner, external sounds, like the sound of a grenade explosion, are experienced as a powerful personal sensation that is immediately internalized and felt as though it happened in the real world (or something close to such an experience)," Afshar says. "The trick was finding how to extract the haptic information from ordinary audio that's available in all forms of entertainment such as games, music and movies."

From Kickstarter To Kicking Your Chest

KOR-FX has at least one thing in common with Oculus VR's buzzy virtual reality headset: Both rocketed to success by using The People's Venture Capital Firm: Kickstarter. On June 9, 2014, Immerz launched the KOR-FX Kickstarter project, seeking a \$75,000 investment from prospective backers. The community jumped all over the project, ultimately raising over \$180,000 to make the KOR-FX a reality. Immerz began shipping the vest last year, starting with its Kickstarter backers, but the company can trace its history back to 2009, when Immerz developed the first prototype.

"The whole process was exciting," says Immerz CEO Seth Fandetti. "Kickstarter was a great experience and helped us build a community of like-minded enthusiasts who wanted to try our product and help fund the project. The community gave us great ideas and suggestions about what they wanted from a haptic gaming vest."

In 2009, the first-generation KOR-FX vest wasn't a vest at all. The plastic harness looped over the wearer's shoulder and looked like a pair of headphones lying flat against the chest, just below the collarbone. After developing two successive plastic prototypes in 2010 and 2011, Immerz realized that a different approach was needed to bring the KOR-FX to market. In 2012, the company began experimenting with various types and

sizes of vest for the KOR-FX. For the next two years, Immerz honed its vest design.

"Getting the ergonomics right, so that the unit is both unisex and one-size-fits-all, was the most challenging aspect of developing the KOR-FX," Afshar says. "It took a few years to finally converge on the vest form factor as the most flexible and universal design, allowing for quick mounting and removal, easy adjustments, ease of use in any position or sitting arrangement, and, most importantly, total comfort during long gaming sessions." Afshar says that Immerz wanted the KOR-FX to be comfortable to the point that gamers forget they're wearing it.

Last year, the company settled on a final design and took it to E3 just days after launching the Kickstarter campaign. The move worked, as Immerz reached its \$75,000 goal a week later. After that, KOR-FX was no longer a prototype; it was a product. Then the real work began, as Immerz ramped up production to fill the orders of the over 1,000 backers who contributed enough to receive a KOR-FX vest.

Suit Up

The KOR-FX system consists of two pieces, the KOR-FX vest and a wireless dongle that plugs into a 3.5mm audio source. The 3.5mm plug makes the wireless dongle compatible with a variety of audio sources. As you might imagine, this lets you use the KOR-FX on not only videogames but also music and movies. The dongle has a 3.5mm audio out jack that connects to a pair of headphones. To power the box, you'll need a USB power source or, alternatively, four AA batteries. The vest itself runs on four AA batteries. A pair of dials on the dongle adjust the volume output to the connected headphones/headset and the intensity of the vest's feedback, respectively.

It's a great setup, but the KOR-FX's real magic is the number of "dials and knobs" it has, which lets you customize the KOR-FX's acoustohaptic feedback according to the game you're playing. On the right side of the vest, when you're wearing it, you'll find the power button, the Bind button (which establishes the wireless connection between the vest and



Immerz founder and CTO Shahriar Afshar says that a major turning point in the KOR-FX's development process was determining that a vest "form factor" was the most effective method of making their technology a one-size-fits-all solution.



One of the KOR-FX vest's biggest advantages, aside from its revolutionary acoustohaptic feedback technology, of course, is the sheer degree of customizability. Gamers can configure their vests according to individual games, maximizing the immersive experience.

the dongle), and the Mode button. On the left side are two buttons that adjust the intensity of the vest's haptic feedback.

The two intensity buttons are self-explanatory, but the Mode button requires a brief exploration. Its primary function is to filter out portions of the audio spectrum that trigger the vest. So, for example, on the first setting, the KOR-FX will only utilize the low end of the audio signal's frequency range—in other words, the bass. Moving up to the second setting will include the audio's bass and mids, and this is the setting that Immerz recommends. The third and final setting incorporates the full audio frequency range for the vest's haptic feedback.

The Mode button also helps you position the vest on your body in order to experience the best possible haptic feedback. By pressing and holding the Mode, the vest's transducers will fire at full strength, letting you adjust the vest for the best possible fit and feedback. When you're set, pressing the button again cancels the effect.

Naturally, each game you play will have a different sonic footprint, so you'll want to tweak the KOR-FX accordingly for the

most immersive experience every time. We recommend playing each game for at least a few hours in order to experience all of its nuances, letting you dial in the perfect settings.

Once you've strapped on the vest and are ready to use it, Immerz recommends an 8-hour break-in period before the KOR-FX is able to deliver the perfect acoustohaptic experience. Afshar explains the reasons behind the break-in period: "It is both an issue of the fabric and the internal structure harmonizing to haptics signals. As with any electrical transducer, our ACH transducers reach peak performance and highest efficiency after the initial break-in period."

The Future According To KOR-FX

Despite the fact that the KOR-FX vest has yet to celebrate its first official birthday, Fandetti says that Immerz is already hard at work developing new hardware and software to make acoustohaptics even more immersive. Like any good piece of hardware, version 2.0 of the KOR-FX vest is already under development, Fandetti shares.

"We had tons of great feedback from our customers for improvements they would like to see in the vest," Fandetti says. "We also have a list of improvements we have been working on over the past year that we are going to build into the next version of the product."

According to Fandetti, Immerz is preparing the next-gen KOR-FX with a goal of having it ready when upcoming VR products reach the market. Although he's tight-lipped about specific details, Fandetti reveals, "We are also looking at other forms and application for our haptic solutions in our labs and have some great ideas brewing. . . . In the future we hope to have a full product line of haptics products that complement different applications and uses."

Although the KOR-FX in its current form should work with any game, Immerz is also working on an SDK that will let game developers tweak and tune their games specifically for the vest, which should allow the vest to make games feel even more realistic. Fandetti admits that the process hasn't been without challenges, but he says that Immerz recognizes the value of making an SDK available.

"We would love to give developers the ability to trigger haptic sensations of sorts," he says, "to help them craft and conceptualize their virtual world with visual, audio, and haptic stimulation. Having this type of immersion . . . is going to be critical to making truly immersive titles in the future."

"We still have every intention of bringing an SDK solution to market, but we want to make sure we do it correctly."

Not Your Father's VR

Clearly, we're still a long way away from fanciful implementations of VR, such as a fully functional holodeck. Nevertheless, the virtual reality hardware available to gamers today is miles ahead of its ancestors.

"It's a very exciting time in technology, where being immersed in your environment is the next evolution of many forms of media," Fandetti says. We are evolving our haptic solutions daily and are so excited to show the world the next generation of haptics." ■

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	700W				

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MAX. COMBINED POWER	130W		996W	3.6W	15W
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750GM

100-240VAC 11-5.5A 47-63Hz

DC OUTPUT VOLTAGE	+3.3V	+5V	+12V	-12V	+5Vsb
MAX. OUTPUT CURRENT	20A	20A	62A	0.3A	2.5A
MAX. COMBINED POWER	100W		744W	3.6W	12.5W
	750W				

Direct cables

600G

100-240VAC 9-4.5A 47-63Hz

DC OUTPUT VOLTAGE	+3.3V	+5V	+12V	-12V	+5Vsb
MAX. OUTPUT CURRENT	20A	20A	49A	0.3A	3A
MAX. COMBINED POWER	100W		588W	3.6W	15W
	600W				

The Mighty Z170

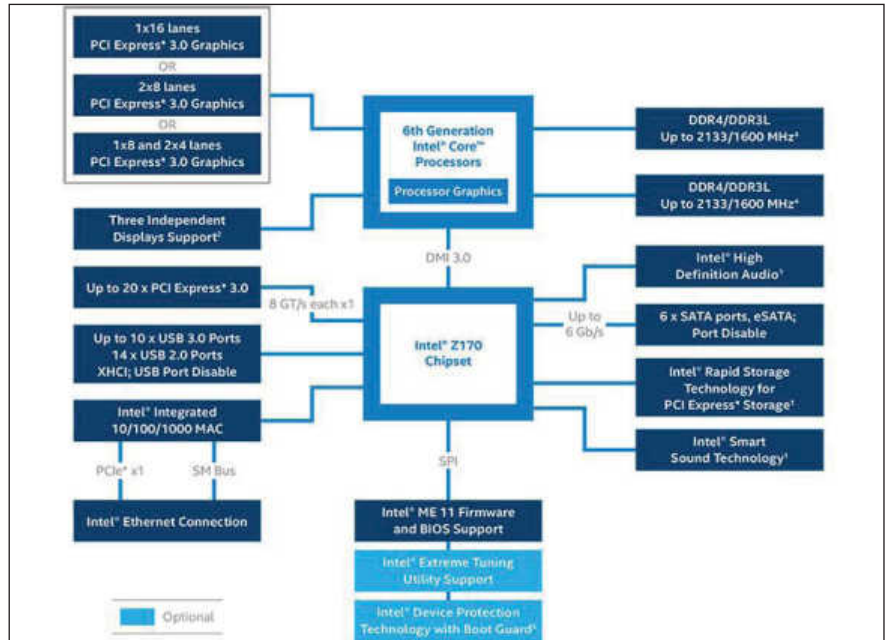
The Muscle Behind The New High-End Skylake CPUs

Intel's new Z170 chipset is still but a baby in terms of the eventual life it will live, but already among gamers, technologists, reviewers, and others, the chipset has seemingly produced a sense of promise, surprise, suspense, confusion, and satisfaction. From day 1, the Z170 has also managed to present an aura of possessing the maturity, poise, and skill set to tackle the performance-minded missions that Intel has created this chipset for. One of these missions was apparently to open some important doors for mainstream performance systems in terms of memory and configurability options for fast SSD storage.

Meet The Z170

Intel officially released the Z170, the flagship chipset in its new 100 Series, at Gamescom on Aug. 5 alongside two new unlocked Skylake 6th Generation Core processors. Both the processors are targeted for mainstream PC use but are also designed to tackle higher performance-level tasks. The processors specifically include the quad-core 4GHz Core i7-6700K (bumps to 4.2GHz with Intel Turbo Boost 2.0 technology engaged to dynamically increase the processor's frequency) and the 3.5GHz Core i5-6600K (3.9GHz with Intel Turbo Boost 2.0 technology). Skylake, of course, is the codename for Intel's new 14nm micro-architecture on which the 6th Generation Core processors are built. The platform follows up on Broadwell, also based on Intel 14nm architecture.

That Intel chose a gaming-centric venue to officially launch the Z170 and Skylake processors wasn't a coincidence. With the Z170-Skylake tandem, Intel created a platform that it's aiming "especially at gamers and overclockers." More broadly, Intel has stated a commitment to the



The new Z170 chipset includes several notable improvements over the Z97 chipset, including providing 20 PCIe 3.0 lanes, up to 10 USB 3.0 ports, and a new DMI 3.0 interconnect.

gaming, performance, and enthusiast crowds with this platform in several ways. Beyond pointing out there are now 1.2 billion PC gamers globally, Intel also declared the PC the top platform for gaming from a volume, revenue, and growth standpoint. Further, Intel hailed gaming as a segment it's taking seriously.

On another front, the release of the Z170 and the entire 100 Series and Skylake family has been one of suspense. While Intel gave us a big spoonful of tastiness to swallow down initially concerning what the platform is capable of, the company then effectively snatched the spoon from our mouths as we were set to really dig in. Instead of giving us more details, Intel effectively closed the kitchen doors for what amounted to roughly two

agonizing weeks until the Intel Developer Forum where the company was to divulge more information about Skylake and the 100 Series.

Post IDF, we still like how that first spoonful of the Z170 tasted in our mouths, but Intel really didn't make Skylake and the Z170 as dominant a theme at IDF as many believed the company would. Instead, it wasn't expected that Intel would make an official and complete announcement concerning Skylake and the 100 Series until early September. For now, what we seemingly know about the Z170 and the top-end Skylake CPUs is that while they aren't going to cause someone who recently plunked down for an extreme-level X99-based motherboard and Haswell-E

processor to change his order, the Z170-Skylake duo is going to serve many a satisfied customer before all is said and done.

Z170 Basics

Before Gamescom, the high-end Core i7-6700K and Core i5-6600K processors understandably garnered the majority of interest among users, including due to general curiosity about what performance bumps Skylake might bring. More broadly, some users were curious about the delays that Intel experienced on



Intel's new high-end quad-core 4GHz Core i7-6700K processor can burst to 4.2GHz with Intel Turbo Boost 2.0 technology and integrates new Intel HD 530 graphics.

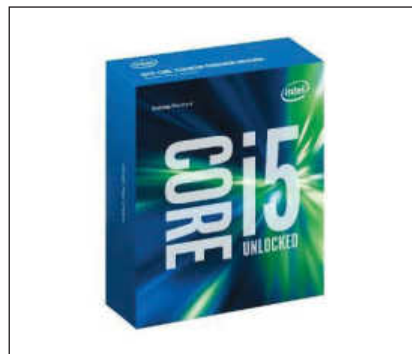
the way to Broadwell 14nm chips and in what ways, if any, those delays might carry over to Skylake.

After Gamescom, however, there's a strong argument to make that the Z170 not only stole a chunk of the Skylake processors' thunder but also emerged as the platform's real star. Beyond painting the chipset as a marked improvement over the Z97 chipset from the 9-Series, many praised the Z170 as being everything from a long, overdue refresh to something worth of the price of a platform upgrade alone. Overall, there's plenty complimentary to note about the Z170.

With the Z170, Intel has carried over some features from the Z97, such as inclusion of Intel HD Audio and an integrated gigabit Ethernet MAC.

Essentially, though, marrying the Z170 with a high-end Skylake processor gives gamers and enthusiasts a platform that ushers in an age of DDR4 memory support for mainstream-level systems. Further, the Z170-Skylake platform takes a major step forward for this space in terms of PCIe 3.0 and bandwidth abilities, while simultaneously offering more fine-tuning for overclocking. For motherboard makers, the chipset has gifted them with a significant amount of flexibility in terms of I/O, storage, and general configurability options.

Something that may knock off some the Z170's luster for some potential buyers is that with the chipset, Intel is also introducing a new LGA 1151 socket in which either a Core i7-6700K or Core i5-6600K processor will sit. The LGA 1151 socket sports one more pin than the LGA 1150 socket that resides on



The new 3.5GHz Core i5-6600K processor can bump up to 3.9GHz with Intel Turbo Boost 2.0 Technology, but it lacks Hyper-Threading support.

Haswell/Broadwell-based motherboards. That means a Haswell/Broadwell processor won't work with a Z170-based motherboard, and a new Skylake Core i7-6700K or Core i5-6600K processor won't work on a Z97-based motherboard. The Skylake processors also won't work on an X99-based motherboard. Positively, Intel has extended compatibility for the heatsink mounting, so air and liquid coolers from LGA 1150-based

motherboards should work with the LGA 1151 socket.

Long-term, the Z170 and Skylake processors shouldn't dry up support anytime soon for the Z97, as numerous users are still seeing a satisfying return on investment for Z97-based systems. The same is definitely true of the X99, which of course supports the beastly eight-core 3GHz Haswell-E Core i7-5960X. The Haswell-E also supports DDR4 RAM (up to 64GB at up to 2,133MHz) and supports up to a massive 40 PCIe 3.0 lanes. It's also worth noting that as we neared press time, Intel was reportedly dealing with a shortage of Core i7-6700K and Core i5-6600K processors, though scores of motherboard makers had already made numerous Z170-based motherboards available. (See our roundup in this issue of Z170-based motherboards for more details.)

The Skylake Factor

It's impossible to detail the Z170 without noting its relationship with the Core i7-6700K and Core i5-6600K processors. As mentioned, these Skylake processors aren't Intel's first foray into producing CPUs for consumers based on 14nm technology. The mobile-centric 14nm Broadwell Core M processors debuted in 2014, but only after Intel overcame delays in shrinking from 22nm to 14nm. It was only in June this year that 14nm desktop-aimed Broadwell CPUs surfaced with the Core i7-5775C and i5-5675C, a release that left some wondering if Intel would even release Skylake processors this year. When Intel did just that, others were confused as to why the company followed up on the Broadwell CPUs just months after their release with another 14nm-based processor and how the two processors lineups would fall in line.

Despite the confusion, Skylake is definitely here. The quad-core Core i7-6700K supports Intel Hyper-Threading Technology, thus the ability to create eight simultaneous threads. The Core i5-6600K lacks Hyper-Threading support. (One interesting rumor coming out of

IDF concerning the Skylake processors was that they possess a new “reverse Hyper-Threading” like feature that essentially enhances the performance on single-threaded workloads by uniting the performance from multiple cores into one virtual core.)

While the Core i7-6700K has 8MB of level 3 cache, the Core i5-6600K uses 6MB. Both processors operate at 91W TDP (thermal design power) and integrate new HD 530 graphics, which is stated to run 20 to 40% faster than the last generation of HD graphics, support up to three independent displays (reportedly Skylake processors will be able to power three 4K displays at 60Hz), add DirectX 12 compatibility, and feature a 350MHz base frequency and up to 1,150MHz max dynamic frequency.

One of the more important aspects pertaining to the Z170 and high-end Skylake processors concerns the platform’s shift to DDR4 memory away from DDR3 RAM, for which Intel first introduced support back in 2007 with the Intel 3 Series. Though it’s more expensive, DDR4 offers several key improvements over DDR3, including providing higher frequency potential, the ability to operate at a lower voltage, and providing greater module densities. DDR4 runs at 1.2V vs. 1.5V for DDR3. The reduction in power consumption, of course, means less heat produced, which should lead to lower internal temperatures. Stock speeds for the memory types, meanwhile, measure 2,133MHz for DDR4 vs. 1,600MHz for DDR3. Similar to the Z97, the Z170 supports dual-channel memory, which compares with the quad-channel memory that the X99 chipset supports.

Technically, the dual-memory controller that the Core i7-6700K and Core i5-6600K integrate will support DDR3 memory, although only the lower-voltage DDR3L type running at 1.35V. Still, users will only be able to plug DDR3L modules into a Z170-based motherboard if the motherboard maker specifically cooks supports into the given motherboard for DDR3L memory.

That’s something that reportedly few motherboard manufacturers plan to do with their boards, at least early on.

Compared to the up to 32GB of DDR3 RAM the Z97 supports, expect most Z170-based boards to support a maximum of 64GB of DDR4. A look at flagship motherboard offerings from Gigabyte, Asus, and MSI, for example, show DDR4 RAM support reaching this mark. Browsing the specifications of Z170-based boards from various motherboard makers indicates that

development concerning the high-end Skylake platform is the major movement forward the Z170 makes compared to the Z97 in terms of high-speed I/O lanes provided via PCIe 3.0 and USB 3.0. Overall, the potential the Z170 enables for today’s newer, faster high-performance storage options, including M.2 drives, is pioneering.

The Core i7-6700K and Core i5-6600K both have 16 PCIe 3.0 lanes tied directly to the CPU that graphics cards primarily will exhaust. These are



The stock Z170 chipset doesn’t natively support USB 3.1, but motherboard makers can add support via the use of a controller. The MSI Z170A Gaming M7, for example, includes onboard USB 3.1 Gen2 ports, including Type-A and reversible Type-C ports.

makers are providing support for DDR4 speeds that extend well beyond the stock 2,133MHz rate. In coming months, expect pricing for DDR4 to continue to decrease and memory makers to increasingly scale to 16GB single module capacities.

PCIe Lanes Galore

Certainly, DDR4 coming to mainstream gaming desktops is worth getting excited about. Another exciting

configurable for one graphics card with 16 PCIe 3.0 lanes (x16), two cards with eight PCIe 3.0 lanes each (2 x8), or three cards with one card getting eight lanes (1 x8) and two cards getting four lanes (2 x4). Another 20 PCIe 3.0 lanes, however, are available from the Z170, each at 8Gbps. That’s 12 more PCIe lanes than the eight that the Z97 supports. Moreover, the Z97’s lanes are all of the PCIe 2.0 variety, meaning they run roughly at half the rate as PCIe 3.0 lanes.

Elsewhere, the Z170 maintains support for up to six SATA 6Gbps ports and one SATA Express port that users can use as two SATA 6Gbps ports. The overall expansion in lanes and bandwidth with the Z170 means a user, for example,

also makes the Alpine Ridge controller available for handling adding USB 3.1 support. The Alpine Ridge controller also supports Thunderbolt 3.0 (up to 40Gbps).

and six 6Gbps SATA ports or two M.2 and 1 SATA Express with two 6Gbps SATA ports.

A Step Ahead

In the months ahead, the Z170-Skylake platform will undoubtedly turn up more interest and likely more surprises. Just weeks after the chipset's release, for example, overclockers were having a field day with the platform. Intel itself refers to the high-end Skylake processors and Z170 platform as marking a return to full-range base-clock overclocking, meaning finer tuning in changing unlocked multipliers and the BCLK (base clock) frequency. In mid-August, a Hong Kong-based professional overclocker using liquid nitrogen reportedly pushed the i7-6700K's 4GHz stock clock speed to just shy of 7GHz,

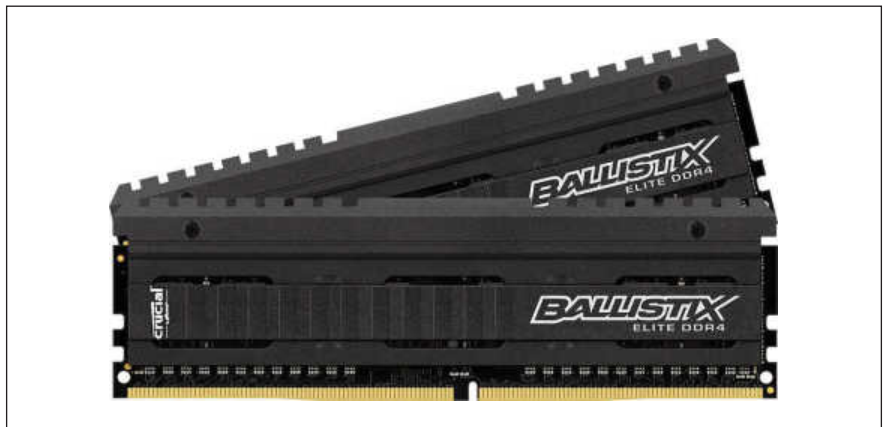
can run a M.2 SSD at PCIe 3.0 speeds without having to steal bandwidth from a graphics card. It also means a motherboard maker could enable installing up to three M.2 drives via x4 PCIe 3.0.

Early on, it appears motherboard makers will devote 4x PCIe 3.0 lanes per M.2, with some including multiple M.2 slots with RAID functionality.

In addition to the PCIe 3.0 lanes, Intel has enhanced the DMI (Direct Media Interface) interconnect between the chipset and CPU with the Z170, moving away from a DIM 2.0 interface based on PCIe 2.0 (rated at 5GT/s) to a new four-lane DMI 3.0 interface (rated at 8GT/s). Like the Z97, the Z170 maintains support for up to 14 native USB ports, however 10 of the 14 now support USB 3.0. The Z97 only supports up to six USB 3.0. Though the Z170 doesn't natively support speedy USB 3.1 ports, which at 10Gbps doubles USB 3.0 speed, motherboard makers can use a third-party controller to add support. Asus' Z170-Deluxe, for example, includes both Type A and Type C (complete with reversible connector) USB 3.1 ports.

Among the motherboards in our roundup, USB 3.1 was pretty much standard. The MSI Z170A XPOWER GAMING Titanium Edition, for example, adds USB 3.1 support via the ASMedia ASM1142 controller. Intel

Overall, the Z170 has 26 high-speed I/O ports available (compared to the



The Z170 chipset and new high-end Skylake processors bring with them the benefits of DDR4 RAM, such as Crucial's Ballistix Elite DDR4.

Z97's 18), providing motherboard makers considerable flexibility in configuring these as USB 3.0, PCIe 3.0, or SATA 6Gbps. Of the 26 ports, the first six are set as USB 3.0 by default, leaving 20 ports that are divided into five groups of four PCIe 3.0 lanes. The MSI Z170A XPOWER GAMING Titanium Edition from our roundup, for example, includes two M.2 ports, two SATA Express ports, and eight 6Gbps SATA ports, although the maximum configuration is one M.2

marking an incredible 75% improvement (albeit not before disabling Hyper-Threading on three cores and adding 0.688v to do so).

Ultimately, if reports hold true, there will be five other chipsets joining the performance-aimed Z170 in the 100-Series. These look to include the H170 aimed at the mainstream space, H110 for the value space, Q170 and Q150 for the corporate sector, and the B150 for the small and medium business sector. ■

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How Fast Is Your PC?

Tune & Optimize With Benchmarks

Congratulations, you've just put the finishing touches on a brand new rig, and all that shiny new hardware is humming along nicely. At this point, the average Joe would probably call it good, but "working as intended" is just a checkpoint along the way to a power user's end goal. Like a sprint car is meant to be raced, your rig will tap into all of the speed its hardware can provide—and maybe even a little more via overclocking. How does one go about fully realizing a system's potential? Benchmarks help you to decide if a tweak to the CPU or memory is worthwhile, or maybe if you'll want to add a second GPU for SLI or CrossFire for even greater performance.

Even if you're not looking to amp up performance, benchmarks are a good way to make certain your components are functioning like they should. "There are many subtle problems that benchmarking can pick up," says David Wren, technical director at PassMark Software. "For example, wrong video card drivers, RAM not being in the optimal slots, XMP and AHCI not being enabled in BIOS, or the wrong power-saving plan being selected in Windows." Benchmarks are the proof in the pudding, so to speak.

Types Of Benchmarks

There are two common types of benchmark tests: synthetic and real-world. A synthetic benchmark is a standardized test, or suite of tests, that assesses various PC attributes. The synthetic simulations are typically designed to specifically push a given component, such as your processor, system memory, or storage, at or near 100% workload. This way, you can be sure that your hardware is running flat out for maximum possible performance.

Synthetic benchmarks will often run multiple, isolated tests, so you can measure different aspects of a particular component. With PassMark Software's PerformanceTest, Wren tells us that "Each test suite is composed of a set of individual tests that target a particular area," and he explains that "the disk test suite, for example, contains a read, write, and seeking test." Each tested result is displayed next to baseline results for

Benchmarks let you see if your components are functioning as they should.

similar components. "If there is a specific individual test result that is bad compared to the baseline then it helps narrow down the problem and provides a starting point for an investigation," says Wren.

Another benefit of synthetic tests is that the benchmarks are easily repeatable, so you can be sure that any comparable online results were generated using the same tests you ran. "PassMark maintains a database of over 600,000 benchmark results, which we refer to as baseline files," says Wren. "You can download any of these baseline files from within our PerformanceTest software." The searchable results allow to narrow baseline comparisons to systems with similar hardware, such as the same CPU or GPU, to give you an idea of how changing out other parts might improve your overall system performance.

Real-world benchmarks are ideal if you want your PC to perform well with a particular workload. Some video games come with a standard demo that you can render to run the PC through a real-world instance and provide an FPS (frames per second) rate based on the custom resolution and settings you'd like the game to run at.

Other examples of real-world testing include timing how long it takes your

computer to load Windows and/or other applications (a handy benchmark after you've made system optimizations), or how long it takes the rig's storage devices to transfer a large group of files. Ideally, you'll want to find practical ways to see how fast the PC can finish the tasks you do the most. It can sometimes be difficult to find real-world tests that push certain components to their maximum performance. For example, you'd need to do some serious high resolution video rendering to find the limits of modern memory.

There are pros and cons with both synthetic and real-world testing. With real-world testing, you'll get a good sense of how the machine works as a whole, but real-world benchmarks typically won't break down the results to see how individual components fared. Synthetic

benchmarks, on the flip side, let you accurately compare the performance of individual parts.

For these reasons, we recommend that you start by refining performance using synthetic benchmarks and using real-world testing to see how those changes have affected what you do every day. Here at CPU, we run a variety of benchmarks to evaluate hardware performance. For instance, our latest GPU reviews provide synthetic benchmark results via 3DMark and Unigine Heaven 4.0, as well as real-world FPS rates from *Aliens Vs. Predator*, *Metro: Last Light*, *Dying Light*, and *Witcher 3: Wild Hunt*.

The Scoring System

Numbers are your friend when it comes to dealing with benchmark results. There will be no shortage of digits to write down and/or enter into a spreadsheet. Unlike the Windows Experience Index, the figures range from much more than 1 to 7.9. Benchmark scores are often in the thousands, and typically represent a relative figure in regard to PC performance. For example, a CPU Mark score of 12,000 in PassMark Software's Performance Test utility represents a CPU that would process data around twice as fast as one scoring 6,000 in CPU Mark. And when dealing with benchmarks ranking overall system performance, the result is often an accumulated point total for all of the tests.

Because there's no standard scoring system, you won't be able to compare scores among different benchmark utilities. Instead, you'll need to compare the numbers you record with resources online. To ease evaluation, some benchmark utilities will include the scores of comparable parts, or similar builds, after you've run the tests.

"If you are using PerformanceTest, run the full battery of tests and check the 'Mark' values from each test suite (CPU, 3D, 2D, Disk & RAM) to make sure you are getting within a few percent of the average performance for the part in question," says Wren. And if you plan on upgrading parts, it's a good idea to run

benchmarks before and after an upgrade to see how much extra speed you've gained.

Best Practices

To avoid making any faulty comparisons, you want to follow some best practices that assure your results aren't tainted by a Windows Update running in the background or an old driver. Start by closing any software you might have open, and make certain that any background applications, such as anti-virus software, are idle or disabled. If your PC has been running for awhile, it's a good idea to restart it, which will prevent memory leaks from affecting your results. Futuremark recommends that you wait two minutes for startup programs to complete loading.

Before testing, it's a good idea to double check that you've installed the latest drivers for the hardware within your rig. Graphics drivers are especially important, as developers routinely release new updates that increase performance. To make sure you're comparing apples-to-apples, you'll also want to update your benchmarks to the latest version. Benchmark developers must regularly update the software to support new hardware, so using the newest version is critical if you've bought a component that's only been around a month or two.

When testing, it's wise to run the benchmark test at least three times to determine if the results are repeatable. You typically won't see the exact same numbers each time, but the scores should be close. Add up the results and take the median score. Futuremark says that all scores should fall within three percentage points of the median. If the results are not consistent, you'll want to double check the previous best practice steps.

Should everything seem to be in order, install a temperature monitoring software that will indicate if the motherboard has throttled speed. "Our number one piece of advice for a home build is to make sure the CPU heat sink is properly attached," says Wren. "We see lots of cases where the CPU performance is hampered when it overheats and is thermally throttled."

We like Real Temp and Core Temp for monitoring CPU temps, as the freeware applications both log temperatures in real-time and record the highest recorded temperature. Most graphics cards also come with a utility, such as MSI's Afterburner, where you can monitor the GPU temps.

Lastly, you don't want to rely too heavily on one benchmark when system tuning, as differences in testing procedures and hardware architecture might mean that a given component could do extremely well in one test, while



SiSoftware Sandra offers a host of tests to benchmark the individual components of your system.

delivering poor results in a test that puts a similar load on the hardware. Read on to learn more about some of the most commonly used benchmarks.

Meet The Suites

There are a lot of different synthetic testing tools available, and while most specialize in assessing one type of component, there are a few suites that provide a slew of tests to serve as a one-stop shop. Check out our sidebar on PerformanceTest 8 to see more detail about PassMark's suite.

SiSoftware Sandra 2015

www.sisoftware.net

CPU has long used Sandra's tools for our processor and memory tests, and over time, SiSoftware has evolved Sandra

to include benchmarks for most every part in your system, including removable storage, peripherals, networking, mobile device file transfers, and the Windows file system.

Within each Sandra benchmark, there are comprehensive test details, such as performance per thread and performance versus power. You'll also see a list of comparable components and benchmark results for those parts plotted across a graph, so you can visually see where your hardware stands. The individual benchmarks themselves are also robust in how your hardware is tested. For instance, the Processor Arithmetic test runs both Dhrystone and Whetstone tests. The Dhrystone test contains a sample of operations, which are typically numerical, while the Whetstone test is a measure of floating-point arithmetic.

Sandra also doubles as a handy diagnostics tool, as there are integrated burn-in tests to stress test the hardware in your rig. You can run a series of benchmarks that will push the CPU, GPU, memory, and even the network speed to ensure that the entire system can handle demanding loads overtime.

SiSoftware offers a Lite version that's free for personal use, and the Lite version gives you access to many of the key benchmarks. But if you want some of the more advanced features, such as real-time driver, firmware, and BIOS checking, you might want to try out the Personal Edition (\$49.99 for five PCs; <http://www.jaggedonline.com/personal.php?a=>)

Futuremark PCMark 8

www.futuremark.com

PCMark 8 is a benchmark that does a good job of analyzing how well a computer will handle the typical tasks performed by home office PCs. The benchmark suite offers you five test scenarios, including Home, Creative, Work, Storage, and Applications, as well as a general battery life test. There's a free version that will run the synthetic Home, Creative, and Work scenarios. The Advanced edition (\$49.99) supports

the Storage and Application scenarios with real-world testing for Adobe and Microsoft applications, assuming the Adobe Creative (CS6 or Creative Cloud) product or Microsoft Office (Office 2010 or later) products are installed on your system.

The Home benchmark is designed to reflect light workloads and low computational requirements of low-cost tablets and affordable notebooks. With



PCMark 8's Creative test simulates the load created by multimedia content creation tools.

the Creative benchmark, PCMark 8 shifts the workload to match enthusiasts and professional media content creators. In our system testing, we run the Creative benchmark, so you'll get an idea of how a PC will do with the more demanding content creation tasks. In the Work benchmark, PCMark 8 focuses on basic office tasks, including document and spreadsheets. Ideally, you'd run the Work benchmark on a system lacking powerful graphics capabilities.

The Storage test is highly dependent on the real-world speed with Adobe or Microsoft products, so it's great for a getting a sense of how your storage devices will transfer files using those applications. Similarly, the Applications benchmark runs through the actions you normal use with Creative Suite and Microsoft Office. The Battery Life test uses the benchmark scenarios to give an accurate measurement of how long your notebook or tablet's battery will last with everyday tasks.

The mix of synthetic and real-world testing in PCMark 8 provides the best of both worlds for those looking to assess their PC's home and professional abilities. Detailed test results are provided, too, if you're looking to troubleshoot why an overall score might be lower than that from a comparable system. Because the tests aren't always designed to place a 100% load on your hardware, PCMark 8 is less useful than other suites for evaluating individual components, but it is one of the few benchmark suites that's designed to give you an idea of how your PC does with common tasks.

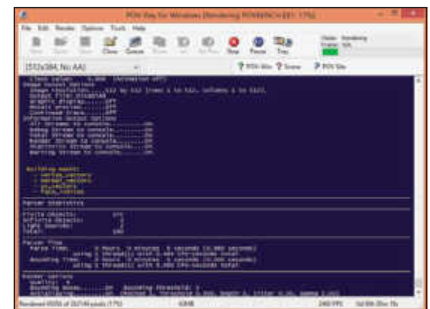
Let's Get CPU Intensive

Because your CPU is one of the most important and fine-tunable components, we often use several benchmarks to analyze performance, including Cinebench 15, POV-Ray 3.7, and results from SiSoftware Sandra's processor specific tests. Here, we'll take a deeper look at the types of benchmarks we run on processors.

POV-Ray 3.7

www.povray.org

Short for Persistence Of Vision Raytracer, POV-Ray is a free 3D animation utility, and it has a built-in benchmark that can handle multi-threaded loads. On first blush, you might mistake the 3D animation test as a graphics benchmark, but the ray-tracing duties of POV-Ray rely almost solely



POV-Ray is a freeware that uses ray-tracing to stress test your system's CPU.

on the CPU. POV-Ray 3.7 provides a standard scene that designed specifically to heavily load the CPU. In fact, we use POV-Ray 3.7 in our CPU cooler testing, because it's one of the best benchmarks for stress-testing processors.

Cinebench 15

www.maxon.net

Similar to POV-Ray, Cinebench is test suite is based on an animation software, in this case MAXON's CINEMA 4D. To benchmark your processor, Cinebench 15 renders a 3D scene with around 2,000 objects and 300,000 polygons. MAXON indicates that the benchmark can scale to support up to 256 processor threads. Results are displayed in points (shortened to pts), and the higher the number, the better your processor. The free application

is available for both Windows and Mac platforms.

Pixel Pushers

If you've got a couple games in mind that you want to play, it's helpful to benchmark those titles. If your game doesn't have an integrated performance assessment tool, you can download FRAPS and record the frames per second rate during a manual run-through of the game. We suggest at least a two-minute run—with at least some action—to get an accurate FPS average. There are also a number of well-designed synthetic tests. Read on to learn more about a few of our favorite synthetic game demos.

Futuremark 3DMark

www.futuremark.com

3DMark has been a fixture in high-end system and GPU reviews for years, and in recent releases, Futuremark has added tests to benchmark less powerful hardware. For instance, there's a Sky Diver test designed for gaming laptops and mid-range PCs, and a Cloud Gate test for home PCs and notebooks. Power users will likely use the Fire Strike test, because you can scale the resolution and adjust the rendering workload to fully tax multiple GPU systems.

Those with a single GPU will likely run the standard Fire Strike test that renders video at 1,920 x 1080. The Fire Strike Extreme test ups the resolution to 2,560 x 1,440 and adds visual improvements to better ensure accurate measurements on systems with multiple graphics cards. Fire Strike Ultra bumps the resolution to 3,840 x 2,160, which makes it the most

PassMark PerformanceTest 8

www.passmark.com

The latest version of PerformanceTest comes with more than 32 standard benchmark tests, which are split among CPU, 2D graphics, 3D graphics, disk, and memory suites. After you run the tests on your system, PerformanceTest will save the scores as a baseline, so you'll have a starting point for improving performance. You can also compare these baseline results to the comparable components listed within PerformanceTest, so you won't need to venture onto multiple websites to figure out if your hardware is up to snuff.

PerformanceTest 8 provides a summary "Mark" for each of the major test suites, and these overall grades serve as a way to compare how your PC fared in the different suites. And when you bring up the results from the test suite, there's a graph for each individual test that shows how your hardware performed vs the baseline results for popular alternatives. For example, we were able to compare the Intel Core i7-5960X in our test system versus a Core i7-5820K and AMD FX8150, among others. We also like that PassMark Software provides a percentage rating for how much higher or lower your hardware performed against the other baseline options.

The detailed breakdown gives you a way to see where your hardware's performance might not meet expectations. In the 3D Graphics suite, for

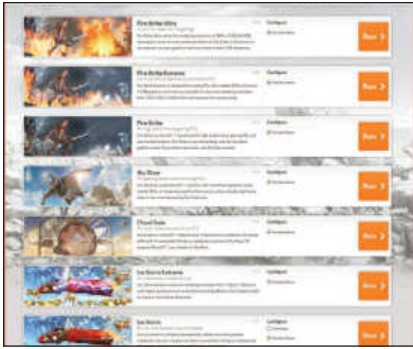


instance, you can view how the GPU performed in PerformanceTest's DirectX 9, 10, 11, and DirectCompute benchmarks. In the Memory tests, you'll find results for Read Cache, Read Uncached, Write, and Latency. If the component is lacking in one area, you can begin to troubleshoot the problem and possibly increase performance as a whole.

"Advanced Tests let you create custom test scenarios and run an in-depth analysis of your hardware's behavior," says Wren. "If for example, you notice that your system struggles especially when saving or copying very large files (e.g. audio or video projects), then you can use the Advanced Disk Test to do some customized testing." Wren tells us that you can configure how large a file to write, the particular access method, and the test duration, so you can simulate the same behavior. In this way, you can narrow down the problem by reproducing similar performance situations.

Overall, PerformanceTest is one of the most complete benchmark suites around. Best of all, you can take PerformanceTest with you by installing the suite (and the license key) onto a USB drive, so you can bench other PCs around the house. PassMark Software offers a 30-day trial, so you can test it out before purchase.

NOTE: For a limited time, PassMark Software is offering CPU readers a 50% discount with promo code **PT8HALFPR**, so you can receive the entire suite for just \$13.50.



3DMark provides a variety of benchmark tests, but power users will most likely want to use the Fire Strike versions.

demanding test in 3DMark. Futuremark indicates that a 4K monitor is not required, but it suggests your graphics card have at least 3GB of memory.

Early this year, 3DMark also added an API Overhead feature test that examines how your GPU will do with the recently released DirectX 12 and other “bare-metal” APIs that provide better access to the raw computation power of today’s GPUs. The API Overhead test allows you to compare the visual performance of DX 12, DX 11, and AMD’s Mantle (AMD is dropping development of Mantle, and passing it along to the Khronos Group for the Vulkan API). Overall, the goal of the API Overhead test is to see how many draw calls your GPU can handle with each API before the frame rate drops below 30fps.

Futuremark offers a Basic Edition of 3DMark that’s free and allows you to run the standard versions of Fire Strike, Sky Diver, and Cloud Gate. If you want to customize the test and enjoy access to the Fire Strike Extreme and Fire Strike Ultra tests, you’ll need to move up to the Advanced Edition for \$24.95. The Advanced Edition also lets you loop the benchmarks for stability testing and save your results offline, so you can compare results after driver and component updates.

Unigine Heaven
<https://unigine.com>

This synthetic GPU stress test is full of tessellation and shaders, as you’ll fly by shiny brass, carved wood, intricate gears to stress test your GPU. Unigine designs the Heaven benchmark to help you determine stability and see how well the GPU’s cooling system does under full load. The Heaven benchmark is 100% GPU-bound, so you won’t have to worry about if the CPU or memory in your system affects the result.

Unigine also lets you customize the settings, such as the intensity of hardware tessellation and shaders. If you plan to use multiple monitors for gaming, you’ll like that Heaven supports several monitor configurations. Real-time GPU temperature and clock speeds are displayed in the upper-left corner, so you can keep an eye on critical metrics during the test. The Basic edition is free and includes almost all the key features. The Advanced edition (\$14.99) adds looping and reporting (in the .CSV format) capabilities.

Storage

SSDs and PCI-E based storage devices have made upgrading your PC’s storage one of the quickest ways to improve performance. And if you want to know which storage is truly the fastest, you’ll need to run and reference benchmarks.

Crystal Dew World CrystalDiskMark
<http://crystallmark.info/?lang=en>

CrystalDiskMark is a quick way to see the read/write speeds for your storage devices. The utility runs both sequential and random tests, so you can compare how a storage device handles different I/O requests. You can customize the test data, as well as the queue depth, if you want to simulate a particular workload. The provided results display the actual throughput, such as 550MBps, rather than a numerical score. Being able to reference the throughput makes it easy to compare the results to the speed ratings provided by the manufacturer.

The two most recent versions (4.0 and 5.0) of the software use a benchmark

core powered by Microsoft’s DiskSpd workload generator, and due to the change, results from CrystalDiskMark 4 and above aren’t comparable to older versions. The DiskSpd is a storage load generator created by the Windows Server and Cloud Server infrastructure engineering teams, so you can be certain the synthetic load reflects real-world scenarios.

AS-SSD
<http://www.alex-is.de>

AS-SSD provides both synthetic and real-world copy tests. With the synthetic tests, you’ll see the drive’s performance with sequential and random (4K and 4K-64 thread) reads and writes. AS-SSD generates these results without using the OS system cache, so the numbers won’t be inflated by load times from SSD caching. There’s also a compression test that measures your drive’s ability to use compressible data. With the first three synthetic tests and the compression test, AS-SSD uses a 1GB file.

When running the copy tests, AS-SSD transfers folders filled with different sized files. There’s an ISO folder with two large files, a Programs folder with a collection of smaller files, and a Games folder with a mix of large and small files. AS-SSD’s broad testing makes it easy to see how your storage devices handle different I/O operations.

A Good Gauge

Once your benchmarks are run, take some time to analyze the results and see where a tweak might improve your overall system performance. And if the benchmarks are in agreement with comparable results, you’ve at least established a baseline for system performance that you can reference after upgrades. Just re-run the relevant benchmarks for your updated hardware and you’ll be able to pinpoint exactly how much faster you’ve made the PC. We think you might be surprised by how much a simple GPU or processor overclock will boost your benchmark results. ■

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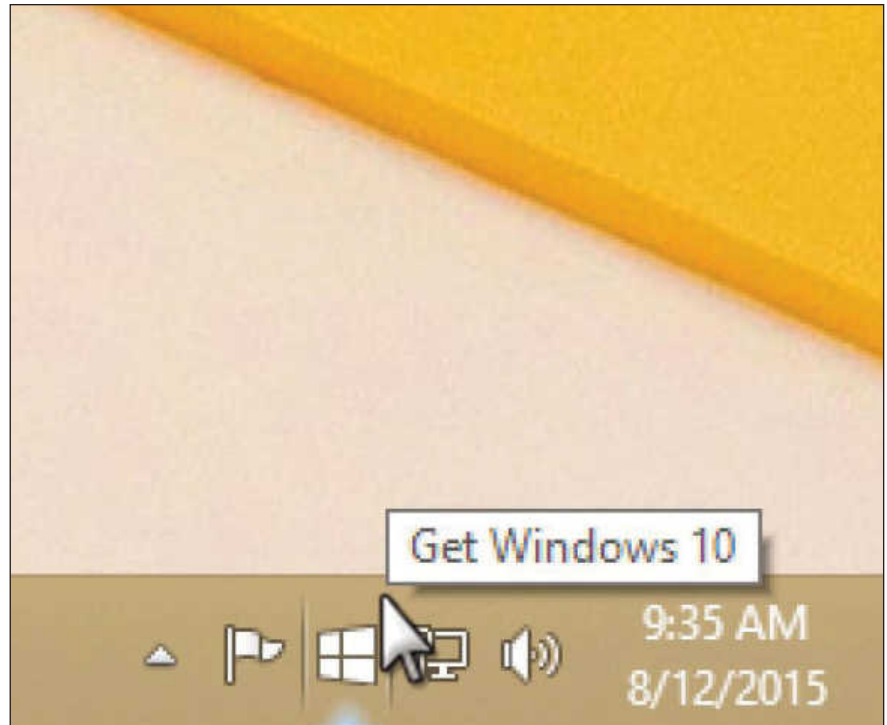
Perform A Clean Install Of Windows 10

Last month we gave you a performance preview of Windows 10, and we were pleasantly surprised with the results. Now, with several weeks under its belt, we can say with relative confidence that Win10 doesn't have any show-stopping bugs; it's time to bid our old OS a fond adieu.

In an attempt to streamline the OS release, Microsoft opted to roll it out as an upgrade, delivered through Windows Update. That's fine for most PC users, but as enthusiasts, we know that we'll get the best performance from a nuke and pave. To do this using a Win7/8.1 PC and Microsoft's free upgrade option, you must first convert your existing license key to a Win10 license key. As we went to press, the only way to do this was to just let the system perform an in-place upgrade. Only after this is accomplished can you then go back and perform a clean install with the help of Microsoft's Media Creation Tool. This multistep process is rather cumbersome, but totally worth it if you want to get back that new PC smell as you make the jump to Win10.

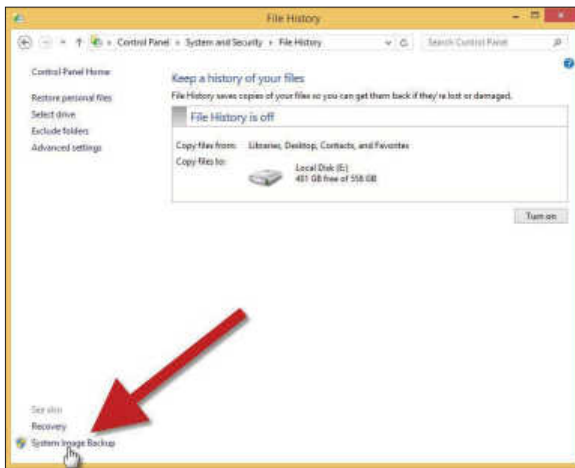
But First . . .

Before we delve into our Win10 clean install tutorial, you need to make the appropriate backups of your data, multimedia files, and any applications you can't easily recover from the web. We recommend manually backing up your important files to removable media such as an external hard drive, DVD-ROM, Blu-ray Disc, thumb drive, or CD-ROM. Additionally, we like to create a quick clone of our current OS drive, which we can recover to in the event that our OS upgrade takes a catastrophic turn halfway through.



The first step is to reserve your free copy of Windows 10.

Before we delve into our Win10 clean install tutorial, you need to make the appropriate backups of your data, multimedia files, and any applications you can't easily recover from the web.



Upgrading to a new version of your OS can be tricky. Protect yourself by making a backup.

In Win7, you can access the cloning utility by opening the Control Panel and navigating to System And Security, Backup And Restore, and then just clicking Create A System Image from the left side of the window. In Windows 8.1, things are a bit trickier. Start by accessing the Control Panel, then navigate to System And Security, then File History. Under the See Also heading in the lower left of the page, click the System Image Backup hyperlink to launch the utility.

Just follow the Create A System Image wizard's instructions to choose a location for your system image to be stored, select a source, and then finalize your settings. Our 65GB OS drive image took less than 10 minutes to complete, but the read/write speeds of the source and destination storage devices, as well as the amount of data to be cloned, will impact how long it takes your system to perform the operation.

The In-Place Upgrade

This is a time-consuming way to effectively convert your Win7/8.1 license key into a Win10 key, but it's a necessary step. To begin, click the Get Windows 10 app icon (it looks like a Windows logo) in the notification area. By the way, if you happen to be

missing the Get Windows 10 app, we have a few troubleshooting tips in a sidebar from the August issue.

The slideshow-style app describes a few of the reasons Microsoft thinks you'll want to upgrade to the new OS, but all you really need to do is click the Reserve Your Free Copy button from the lower left of the window. On the next screen, you're informed that your copy has been reserved. You can input your email address to get an email confirmation, but this

step is entirely optional. Microsoft is rolling out the upgrades in stages, so yours won't likely show up right away; you may need to wait a few days or even weeks. At this point, all that's left to do is sit back and wait for your number to be called.

Do I Really Need To Wait?

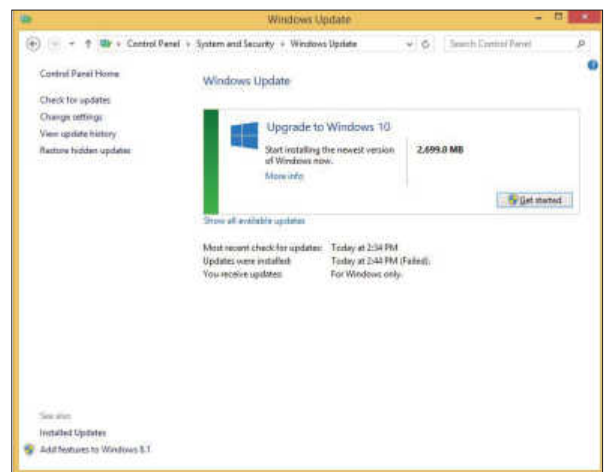
If you're as impatient as we are, there's an unpublicized way to jump the line and get your upgrade right away. (We tested this on a PC running Win8.1.) Start by making sure you've installed every last update from Windows Update. When you see the Your Device Is Up To Date message, then you know it's time to proceed. Next open Windows Explorer and navigate to the C:\Windows\SoftwareDistribution\Download folder and delete its contents. If your OS is installed to a drive other than the C: drive, substitute that drive letter in the aforementioned path. Tossing these files wipes Windows Update's cache,

which can be a sticking point for forcing the Win10 download.

The next step is to open the Control Panel, click System And Security, then click Windows Update. Don't click the Check For Updates button yet. Now open the Command Prompt by pressing the Windows key and type `cmd`, which displays the Command Prompt utility in the search results. Right-click the utility and click Run As Administrator. At the prompt, type `wuauclt.exe /updatenow`, but don't press ENTER to execute the command yet. Align the Windows Update windows next to the Command Prompt window so you can easily switch between them, or quickly switch between them using ALT + TAB. Click Check For Updates in the Control Panel, quickly switch to the Command Prompt, then press ENTER to execute the command you previously input. If everything worked correctly, you should see Win10 downloading in the Windows Update window.

Although these steps will often do the trick, they didn't work for us. We repeatedly got a generic Windows Update error; however, performing a quick Registry edit solved our issue, and we suspect it'll work for others as well.

Before we start digging through the Registry, keep in mind that accidentally deleting the wrong key, changing the



We had to jump through some hoops, but we finally got our upgrade to show up in Windows Update.

wrong setting, or creating a faulty key could render your system unbootable. Follow these instructions exactly. Again, these steps apply to a PC running Win8.1 Professional. Press the Windows key, type **regedit** and then press ENTER. In the Registry Editor, click File and

then click Export, choose a location, name the file, and then click Save. This backup will come in handy if anything goes amiss.

The next step involves navigating to the OS Upgrade folder. Start by double-clicking HKEY_LOCAL_MACHINE,

SOFTWARE, Microsoft, Windows, CurrentVersion, WindowsUpdate, then double-click the OSUpgrade folder. If you can't find the OSUpgrade folder, right-click the WindowsUpdate folder and click New, Key, then name the folder OSUpgrade. Select that folder,

WINDOWS TIP OF THE MONTH:

A Paranoid's Guide To Windows 10 Privacy Settings

This sidebar is typically reserved for a monthly Registry edit, but considering there's already one in the main body of this month's article, we decided to tackle another topic that's sure to come up as you install Win10: the privacy settings. Microsoft is getting a lot of flak for playing fast and loose with your location data, behavior, search queries, and other computing tendencies. Despite the outcry, you have a surprising amount of control over how much Microsoft (and its partners) know about you and your usage.

In the latter stages in the clean install, you'll have an opportunity to adjust your privacy settings. If you click the Use Express Settings, then you've opened the floodgates. We recommend clicking the somewhat out-of-the-way Customize Settings hyperlink at the bottom.

Under the personalization subgroup, you can turn off speech, typing, and inking input to prevent the OS from sending Microsoft your contacts, calendar data, and the vaguely-described "input data." There's also a switch that lets you disable the use of typing and inking data to improve the firm's recognition and suggestion platform. Feel free to disable the use of a device-specific advertising ID. At the bottom of this page is the location setting switch. Turn it off if you don't like the idea of Microsoft and "trusted partners" knowing where you are and where you have been.

Click Next to access the Browser And Protection privacy settings. The SmartScreen filter, a familiar malicious content blocker, is one of the more innocuous options that you may want to leave enabled. The next switch, if left enabled, sends Microsoft your browsing data in the name of improving reading, speeding up browsing, and generally enhancing the browser experience.

There are three options in the Connectivity And Error Reporting section. The first two let your device automatically connect to open hotspots and automatically connect to networks shared by your contacts, both of which could leave you exposed to malicious users. The last option in this category sends Microsoft error and diagnostic information, which is probably safe to leave enabled.

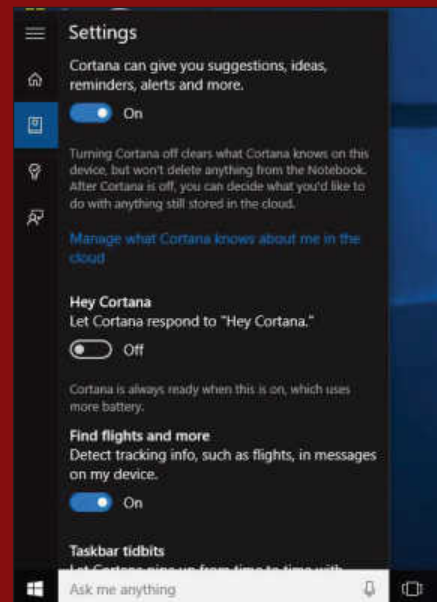
To lock down as much personally identifiable data as possible, you should create a local account rather than signing in with a Microsoft account. During

the install process, you can do this by clicking Create A New Account and then Sign In Without A Microsoft Account options when prompted.

Once Windows is installed, there are a few more tweaks you can perform to keep safe. Click the Windows logo to open the Start menu, click Settings, then click Privacy. If you customized your settings during the install, then many of these switches are already configured. If not, you can disable them now. Click through the various tabs and disable any settings you think go too far. When you're finished, click the Feedback tab at the bottom of the column and set the feedback frequency to Never. Remember, if you're a Windows Insider running the Win10 technical Preview, the feedback options are greyed out.

Disabling Microsoft's personal assistant Cortana can help you keep tabs on the information you divulge. Click the Start button, begin typing to launch Cortana's search feature, click the notepad icon from the left edge of the Cortana pane, then switch her off.

Performing these steps won't completely sever your connection to the mothership, but they will cut down on the data you disseminate. On the flipside, you may find that being picky about your privacy has reduced the functionality of your Win10 computing experience. Thankfully, you can always go back into the Privacy applet and change settings to find the perfect balance.



Taking control over your privacy settings means shutting off Cortana.

then right-click an empty spot in the right pane and click New, then click DWORD (32-bit) Value. Name it AllowOSUpgrade (without spaces), press ENTER, double-click your new DWORD Value to edit it, then type 1 in the Value field and click OK. Close the Registry Editor and turn your attention to the Command Prompt and Windows Update.

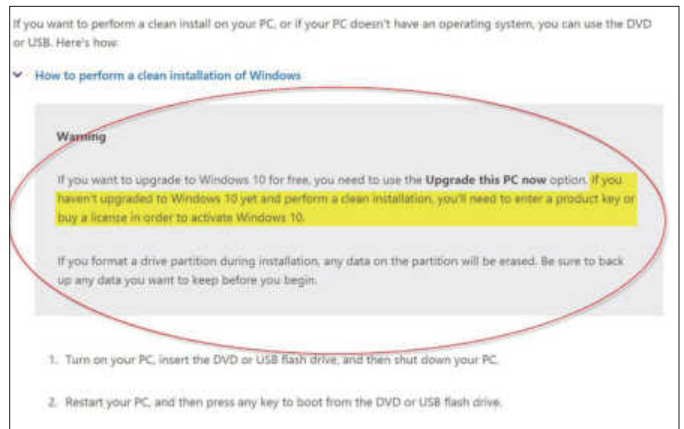
Just as before, delete anything that appears in the C:\\Windows\\SoftwareDistribution\\Download folder, click Check For Updates in the Windows Update window, quickly switch to the Command Prompt and press ENTER to execute the wuauclt.exe /updatenow command. If everything worked, you'll be on your way to installing Win10 in no time. It's about a 3GB file download, though your download time will vary depending on server load and your network connection speed.

When it's complete, you'll have an Upgrade To Windows 10 notification in Windows Update. Click Get Started, accept the software license terms, and then click the Start The Upgrade Now button. (You also have the option to

schedule the upgrade for later.) After a couple restarts between copying files, installing features and drivers, and configuring settings, Win10 will be fully operational on your PC. The process took less than an hour on our system, but this will vary from PC to PC.

The next step is to make sure the Win10 license has been activated. Right-click This PC (similar to My Computer in previous OSes) and then click Properties. At the bottom of the System windows is where you'll see the activation status. If it's not activated, click Activate Windows Now (assuming you're still connected to the Internet).

It's also a good idea to note your version of Win10 and whether it is



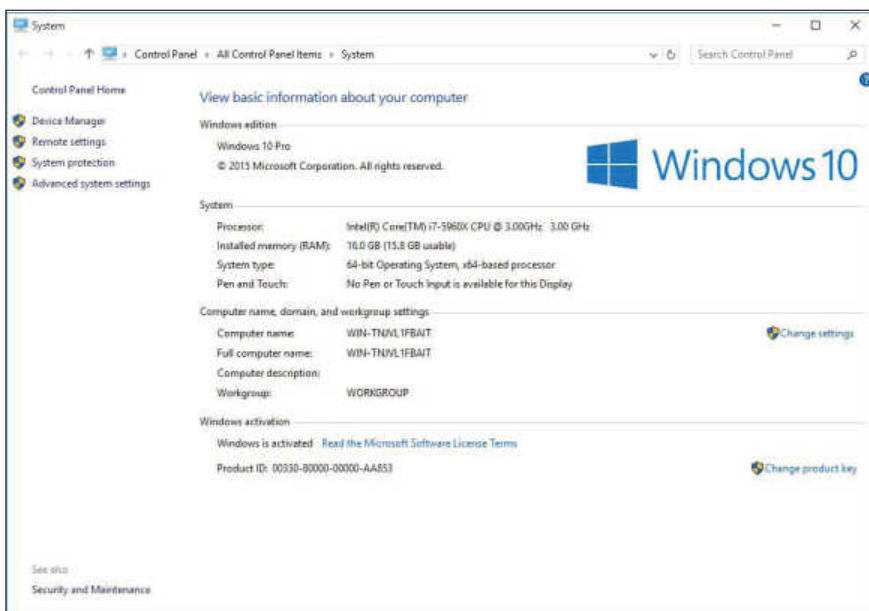
If you perform the clean install before converting your Win7/8.1 key into a Win10 key, you'll need to purchase a license.

the 64-bit or 32-bit version. As we explained in last month's article, if you're running Win7 Home Premium or Win8.1 Home, you'll get upgraded to Win10 Home, and Win7/8.1 Pro users can likewise expect to get Win10 Pro.

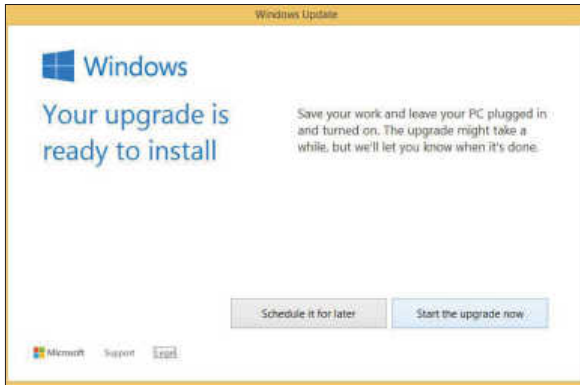
Windows 10 Download Tool

Now it's time to obtain the Win10 installation files, put them on a bootable USB drive, and finally perform the clean install. Start by visiting tinyurl.com/nwvexuv and click the version that corresponds to your OS (32-bit or 64-bit). Choose a location for the file and save it. Double-click MediaCreationToolx64.exe, dismiss the UAC prompt if it appears by clicking Yes, click the radio button adjacent to Create Installation Media For Another PC, then click Next. The following screen tasks you with choosing language, edition, and architecture settings, so make the appropriate selections and click Next.

We're opting to use a USB drive, so we inserted a 4GB drive (the utility calls for at least a 3GB drive) in an available USB port on the PC. This screen also offers to download the files as an ISO that you can burn to a DVD or Blu-ray Disc. Click Next after



Once Windows is activated, you're in the clear.



When everything is downloaded, Microsoft lets you choose to upgrade immediately or schedule the upgrade for later.

making your selection. If you see your USB drive or optical source listed on the following page, click Next to begin the process. This took a few minutes for us, but again your connection speed will be the major determining factor regarding download speed. The utility then automatically begins creating the media drive. After a short period of time, the USB drive is ready to use as clean install media for Win10.

The Point Of No Return

Now it's time to perform the clean install. Remember, this task starts with a complete wipe of your storage device, so now is a good time to go back and double-check the integrity and comprehensiveness of your backup efforts. If you have additional storage devices, you can protect them from accidentally getting wiped by powering the system down, unplugging it, and removing the data cables to all but the OS drive.

When you're all set, make sure the USB drive is in a port on the PC you're performing a clean install on, and then boot the PC, accessing the BIOS Setup menu by pressing DELETE, F1, or whichever key your system requires. You may need to consult your documentation if the boot screen does not reveal the appropriate key. Next, change the boot device order so that the USB drive is the first on the list.

When the boot order is properly configured, save your settings and restart.

The first thing you'll see is the language, time and currency format, and keyboard layout selection screen. Make your selections (or leave them at the defaults where appropriate) then click Next. Click Install Now, and on the next screen, skip the Enter The Product Key step by clicking the hyperlinked

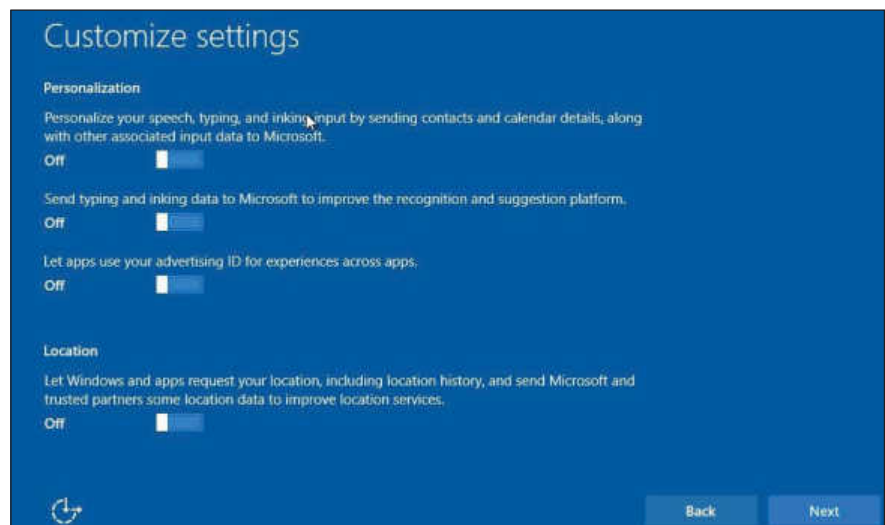
text in the bottom right, click the checkbox to accept the license terms, click Next, then click Custom: Install Windows Only (Advanced). On the drive selection screen, we recommend deleting each partition. When you're left with one large block of unallocated space, click New, Apply, and then

the first boot device, then save changes and exit to reboot the system. When the system boots for the first time from the storage device, you'll get hit with another product key request, but you can click Do This Later to proceed.

On the following screen you can click the Use Express Settings button to get started quickly or click the Customize Settings hyperlink in the lower left of the screen to take a more active role in your privacy settings (see the "A Paranoid's Guide To Windows 10 Privacy Settings" sidebar for more details). After inputting or skipping the Microsoft account and username screens, you're parked back at the Win10 Desktop. If you disconnected any auxiliary drives, now's the time to shut down, reconnect them, and restart.

Now The Real Fun Begins

Once your computer reboots, it should automatically jump online and activate.

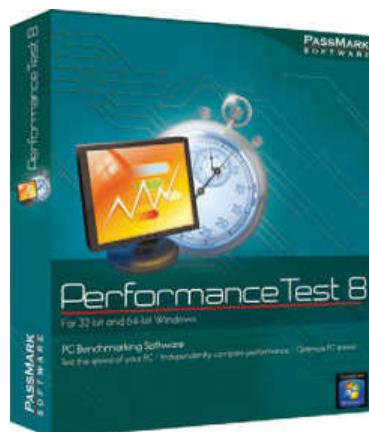


It's a good idea to make a few settings tweaks as your computer finishes the install.

OK to allow the installation to create new system, reserved, and recovery partitions. Click Next to commence the installation of Windows.

When the install process completes, jump back into the BIOS Setup menu and make sure your fresh OS drive is

When this is done, you're ready to begin the long uphill battle of reshaping the UI to your preferences, reinstalling drivers and programs, and remapping drives to suit your needs. Now, when people ask if you've installed Microsoft's latest OS yet, you can say, "Yes, twice." ■

**PerformanceTest 8**

\$27

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PassMark PerformanceTest 8

For benchmark results to provide truly valuable insight, you must compare the numbers with similar hardware. And while online reviews and benchmark websites can provide some decently comparable results, online research can be time-consuming. PassMark PerformanceTest is a benchmarking suite with baselines built into every test. When you run PerformanceTest's CPU benchmarks, for instance, you'll see how similarly priced CPUs perform, as well as a graph with each individual test that displays how much faster or slower your CPU did against comparable processors.

Within PerformanceTest, you'll also be able to search for a given component, such as a GeForce GTX 980, and find benchmark results that other PerformanceTest users have uploaded using the hardware in question. Just click the Baseline tab and select Manage Baselines to find the benchmark results of PerformanceTest users with the same hardware. Best of all, there are Find Same CPU, Find Same GPU, and Find Same CPU + GPU buttons to query rigs with the exact hardware as yours. And because PerformanceTest lists the complete system specs with each comparable system, you can spot where an upgrade, such as more

memory or a faster SSD, could provide a significant boost to benchmark results.

PerformanceTest 8 is the latest edition, and PassMark Software loads it up with 32 standard tests, plus a host of customizable tests. The standard tests fall under CPU, 2D graphics, 3D graphics, disk, and memory suites. After you run the suite's tests, PerformanceTest displays an overall "Mark" score that reflects collective hardware performance. For example, the Memory suite includes individual Read Cache, Read Uncached, Write, and Latency tests that are tallied into overall memory mark. The baseline scores serve as a frame of reference when comparing your rig's individual components against others.

Beyond the overall suite score, you can delve into test results to see if there's a particular area where your hardware is struggling. For instance, the CPU suite offers Integer Math (a basic operation in computer software), Compression (a common task for backup software), and Single Core tests (rates how well CPU might do with apps that only access one core). If an improvement is necessary, you can look at comparable processors' results to see if those chips might improve upon your current CPU.

If you're looking to get more in-depth with a given hardware, you can run the customizable tests with PerformanceTest 8. For example, there's an Advanced Disk test that lets you alter the file size, block size, and cache to test the speed of your storage devices with different workloads. We also like the Advanced 3D benchmark, as you can change the resolution, level of anti-aliasing, and scene detail. By adjusting these settings, you can determine how a card might perform at games when using similar in-game settings.

When it comes to ease of use, it's tough to beat PerformanceTest 8. The boatload of comparable results allow you to make objective decisions about whether or not your hardware is performing at its best. Power users can customize those tests to assess how components handle other workloads or other specific requirements. PassMark is looking to support DirectX 12 and Oculus Rift with future releases, so you can be certain the suite will be ready for up and coming hardware.

BY NATHAN LAKE

(For a limited time, *CPU* readers can get a 50% discount on PerformanceTest 8. Visit www.passmark.com, purchase PerformanceTest, and enter promo code PT8HALFPR to buy it for only \$13.50.)

Platforms: Windows 10; Windows 8; Windows 7; Vista; XP SP3; 2003 Server; 2008 Server; 2012 Server

System Requirements: 1280 x 1024 pixel display; DirectX 9.0c or higher; 1GB RAM; 100MB free HD space (plus additional HD space to run the Disk test and the advanced CD burn test)

Enjoy The Trip

Experience Google's Dreaming Artificial Neural Network

Researchers at Google have recently created an artificial neural network capable of identifying real-world objects and patterns in images. This is a very useful trait for a machine to have, since it allows Google—or anyone else with the technology—to automate image classification on a truly massive scale.

Imagine what it would be like if every photo on the Internet, on your PC/smartphone, and everywhere else was instantly searchable by the actual subject matter captured in the image. When a program can actually look at a photo and know what's in it, finding individual photos becomes as easy as finding words in a block of indexed text. You'd never again have to scroll aimlessly through thousands of images, looking at thumbnails for that photo of your firstborn covered in cake or the mountain goat you snapped on your summer trip to the Rocky Mountains four years ago. Just type "cake" or "goat," and it's there in the blink of an eye.

This method of classification is the holy grail of image search, and it's vastly preferable to the way images

are currently classified, most often by the context of the image within the surrounding text or via the image's metadata. We all know the frustration of receiving row after row of false positives as the results of an image search on the web.

Beyond image classification, artificial neural networks can be used for speech recognition, facial recognition, and other forms of computer vision. The engine that powers Google's artificial neural network is a learning algorithm, which also provides the basis for modern artificial intelligence. Although Google's work is ongoing, the research has already yielded some unexpected and creative results.

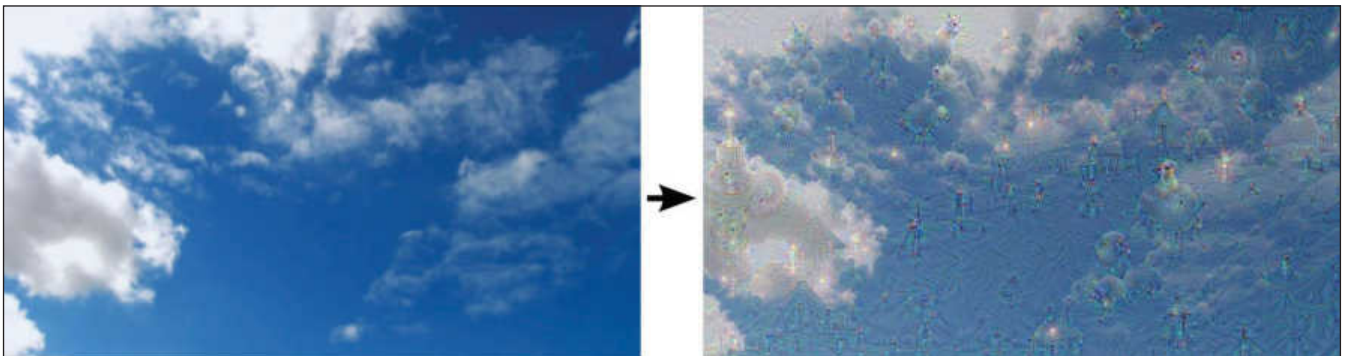
Google's Latest Brainchild

In their endeavor to classify images, the researchers created a multi-layer network of filtering nodes, or "neurons," each one designed to identify patterns in an image and associate those patterns with real-world objects. At the lowest levels, the neurons detect simple shapes, edges, colors, and corners. The mid-level layers can highlight more complex shapes and

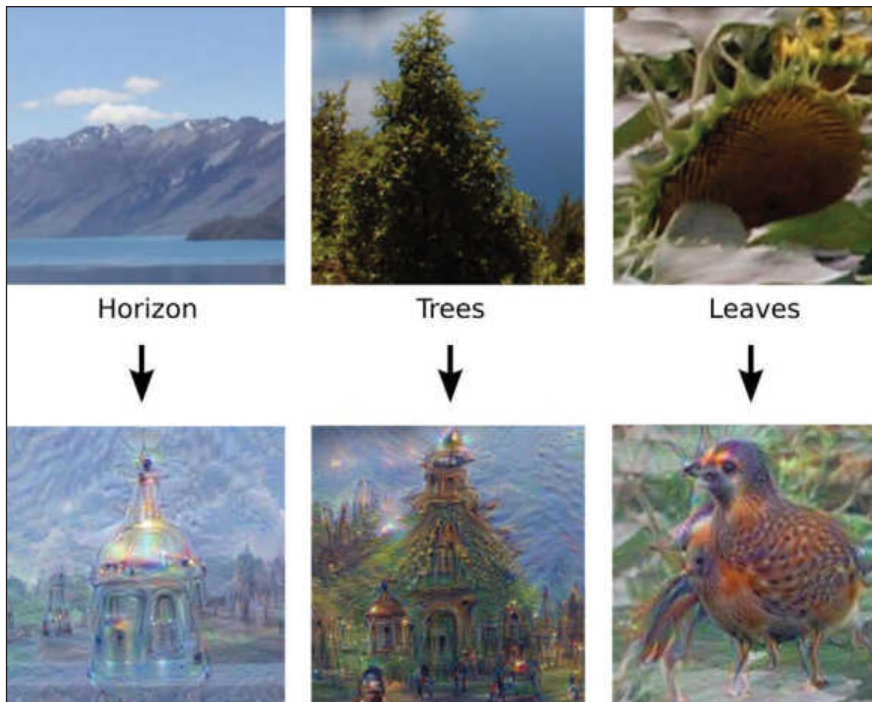
identify components of objects, such as leaves, whiskers on an animal's muzzle, or windows. At the artificial neural network's highest levels, the neurons are trained to detect whole organisms and complex designs, such as trees and plant life, geographic features, buildings, and even specific breeds of animals.

By running virtually any image through these multiple layers (sometimes as many as 30 or as few as 10) of specially configured artificial neurons, the system can effectively tell you about everything contained in the image. That's the ultimate goal, at least; we're not quite there yet.

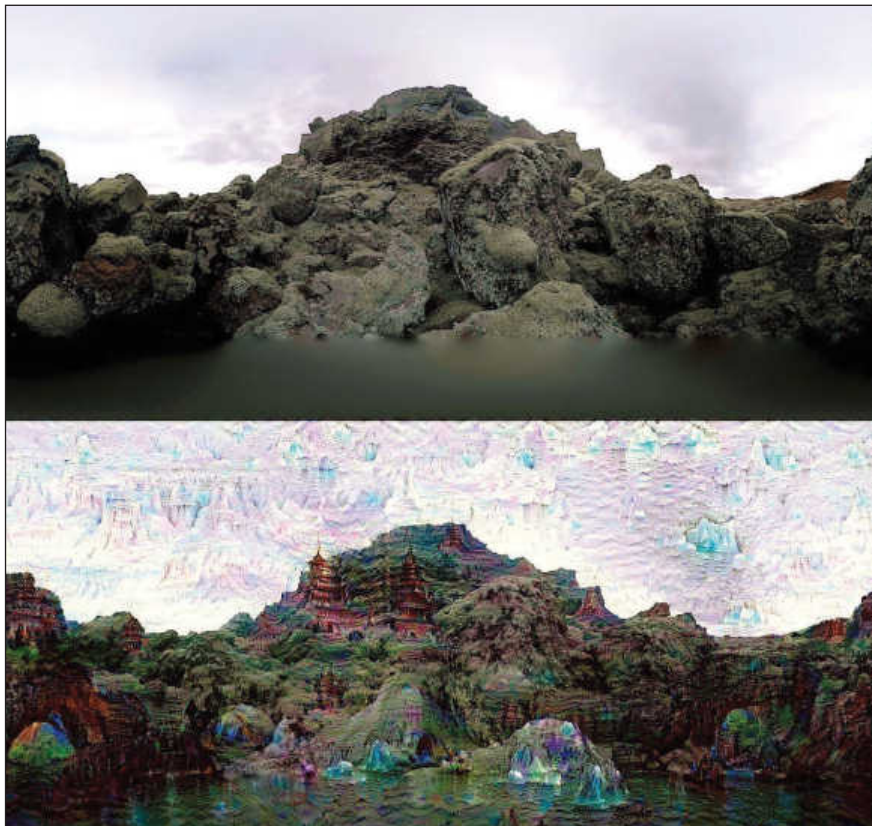
The framework of the neurons consists of a lot of complex math, but as the researchers tweak the formulas behind each of the neurons, they've needed a way to verify whether their experiments are improving or impeding a neuron's ability to identify its specialized patterns. The solution they've stumbled upon is to isolate one or more of the neurons that has been trained to look for specific features, such as edges of objects, or fur on an animal, and then tell it to not only detect but also enhance those



Google's artificial neural networks have an interesting perspective on images.



Some images tend to resolve into unlikely things when filtered by one or more of the neurons.



The researchers use zooming and multiple passes through a filter to get some unexpected results.

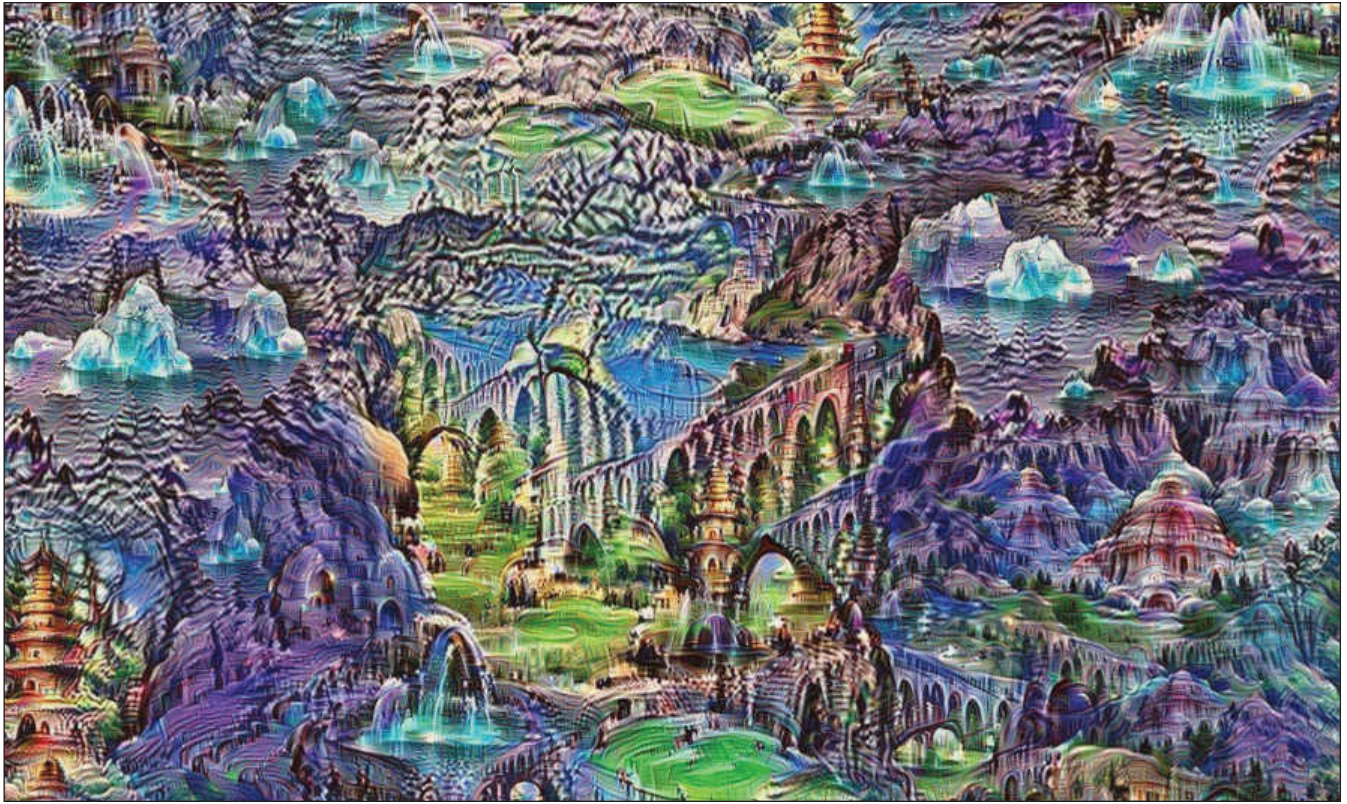
patterns. To perform the enhancement, the network ignores pixels it deems less important and increases the contrast, colors, and other values of the pixels it deems relevant. If a neuron thinks it sees a rabbit in a field of wildflowers, it'll darken the outline of the rabbit's body, for instance. It's the equivalent of asking a machine to take a Rorschach inkblot test and then asking it to add ink to make the image look more like the subject matter it thinks it sees.

But things got really interesting when the researchers began feeding the artificial neural network images that didn't have any existing patterns in them, such as images filled with white noise. This way, the researchers were able to verify that the neuron trained to see dogs is working well when it outputs an image that looks, at least vaguely, like a dog. (Give that neuron a Scooby Snack.)

To give you an example of a neuron that's misfiring, Google's researchers described an instance when they attempted to get the network to find dumbbells in an image of white noise. The resulting output not only showed dumbbells with disproportionate ends but also contained human arms sprouting from the middle of each one. In this case, it was clear that this artificial neural network operated under the false impression that the human hands and arms it often detected in images fed to it during training were an essential feature of dumbbells. As it happens, training a machine to see real objects is harder than you might think.

Machine Art

The images generated by Google's artificial neural network are useful for showing us fairly clearly how they work. But perhaps even more interestingly, the artificial neural network never gets these images quite right and as a result tend to create unusual-looking animals, impossible structures, and psychedelic visuals that are stunning, bizarre, and often beautiful. Examples include simple uniform white noise filtered to



Researchers at the MIT Computer Science and Artificial Intelligence Laboratory have generated a few jaw-dropping landscapes.

display the neural network's impression of a banana and a cloudy sky filtered to look as though it were filled with fantastical alien creatures consisting of dog, cat, fish, bird, and insect parts. These filtered images are being called "dreams." Few would describe the output of an algorithm as "creative" or "imaginative," but it's hard to argue with those adjectives when looking at the network's works.

Isolating neurons and scanning white noise is a good way to troubleshoot the training protocols. But when the researchers let a whole network of neurons perform its enhancement trick on an image with discernable patterns and objects, such as landscapes and animals, they quickly noticed that the output results varied widely—yet consistently—depending on the choice of the original image. For instance, photos of horizons were often filtered and enhanced to appear populated with tiered buildings, images of rocks and

foliage often came out looking like structures, and images of plants and leaves inexplicably morphed into birds and bugs.

The researchers refer to this ability to conjure objects from images of entirely different objects "inceptionism." By taking a more active role in the results, Google's team and other researchers from the MIT Computer Science and Artificial Intelligence Laboratory have been able to tweak the parameters to come up with some really amazing visuals, such as applying the algorithm to an already filtered output, again and again, while performing selective zooming. This results in some pretty trippy interpretations of objects.

Try It Yourself

Following the original post, software engineers and artists who wanted to apply and reapply the artificial neural network's filtering techniques to

their own images inundated Google's research team with requests. In response, the team has released the source code for their trained artificial neural network. The team also provides you with a list of open-source software that you can use to get up and running.

To get started, you'll need to download the IPython notebook found at tinyurl.com/om8p4c2. Grab the Caffe-based code (a deep learning framework) source packages and have installed NumPy, SciPy, PIL, IPython, or a scientific Python distribution such as Anaconda or Canopy. By going this route, you'll be able to supply your own images and determine which network layers to emphasize, how many iterations to apply, as well as how far to zoom in. You can also tap into multiple pre-trained networks for making your own artwork. The researchers even provide a few tips for getting impressive results, including



Using Dreamscope, we managed to create a few trippy images of our own.

offsetting the image by a random jitter, normalizing the magnitude of gradient ascent steps, and applying ascent across multiple scales (or octaves as the researchers call them).

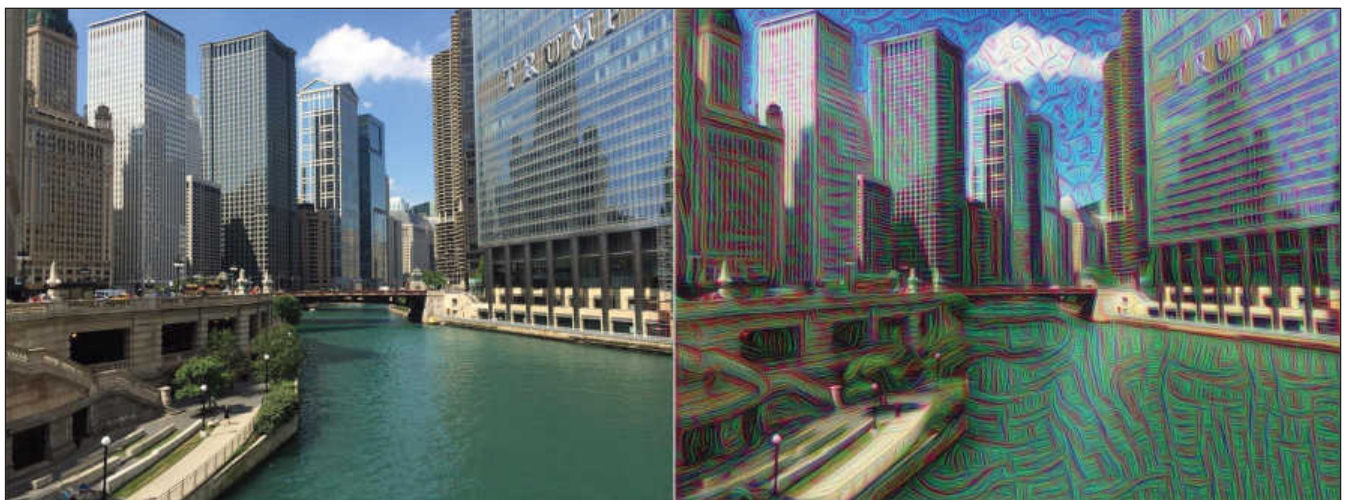
Although this method gives you a lot of flexibility, there's a much easier process for those unwilling to dirty their hands with unfamiliar programming languages. It's called Dreamscope (<https://dreamscopeapp.com>), and it's a web-based application that lets you upload an image and apply one of 19 filters. Just create an account, and start uploading pictures

and choosing filters. You can save your inceptionist images to a private or public album, and download and share them. We've found that downloading and refiltering images again and again can give you some fun results. The site also features dozens of others' artworks that give you a good sampling of what the web app is capable of.

Unexpected Imaginings

Those who use computers and software on a regular basis have probably heard of the concept of GIGO (garbage in, garbage out). It

describes how a perfectly logical computer will only generate illogical or erroneous results when its input was flawed or incorrect to begin with. With artificial neural networks capable of generating such visually arresting results, that concept doesn't seem to apply. Although we can't really explain why these networks are seeing what they're seeing, we can appreciate them as works of art and something to spark our own imaginations. If nothing else, we may have found our answer to the question of whether androids dream of electric sheep. ■



Dreamscope's take on downtown Chicago is undeniably twisted.



Yeah, we know you have blogs to post, video to encode, reports to write, and code to compile. We do, too, but you have to take a break once in a while (and maybe blow some stuff up). That's why each month we give you the lowdown on what to expect from the latest interesting PC and console games.



Cradle is a first-person adventure game set in the future. It explores the fascinating possibilities of transhumanism but goes to great lengths to describe both the obvious and the surprising consequences of shedding the human form in favor of robotic shells called m-bodies. What was at first heralded as a breakthrough for humankind quickly and dramatically alters society into a dystopia of contradictions. Those with more "pure" DNA are elevated to elite status, while those with lower-quality DNA are branded outsiders or ugly people. The game touches on concepts of welfare, inequality, immortality, human identity, and even a form of eugenics.

Having just read that paragraph, you might expect Cradle's setting to be dark, gritty, bleak, and urban. But the events of the game largely take place on a deserted steppe in Mongolia, surrounded by rolling grassy hills and covered by blue skies populated with wispy stylized clouds. A glassy-calm pond is nearby, round striped rocks litter the ground, and twisted trees grow in abundance. The nearby dome-shaped Gerbera Gardens, although rundown and contaminated, is adorned with white and blue tile, covered in colorful sails that gently flutter in the breeze, and surrounded by vast plots of flowers. Bad things have happened here, but all that is in the past now. Or is it?

As a 23-year-old named Enebish suffering from memory loss, you wake up from a strange dream wearing a helmet used to transition a human consciousness into an m-body. You're in a yurt that's crammed with traditional and religious iconography as well as futuristic tech gadgets whose purposes you can't recall. Via hints garnered from scraps of paper, journal entries, and a dilapidated robot lady named Ida (a human inside an m-body), you learn more about who you are, who she is, and what happened to you and society in general. Another m-body you encounter is Tabaha, the driver of a floating railcar who helps kickstart your memory and fills in some of the blanks about the mysterious sterilizing virus that has wracked humanity.

The Bizarre & Mesmerizing World Of Cradle

BY ANDREW LEIBMAN

\$12.99 (PC) • ESRB: Not Rated • Flying Cafe for Semianimals
www.flying-cafe.com

There is a lot going on if you read between the lines in Cradle, but there are a lot of lines to read. On your first playthrough, you will likely miss some tidbits. That being said, this game does pack an emotional punch, especially as Ida learns more about who and what she is with your assistance. But some of the tasks you perform are the very definition of mundane, such as making a bowl of soup for a mechanical golden eagle, retrieving a box of toys buried in the sand, scanning flowers to make "phytocopies," solving riddles, and performing a series of fetch quest mini games. These lattermost segments occur at various points, and although the narrative insists on the importance of these block-collecting platforming sections, they are awkward and punishing. Thankfully you can skip each one if you fail.

The fully-realized universe of Cradle is jam-packed with fascinating revelations and complexity; it feels like the setting of the game is truly the tip of the iceberg. It's a beautiful game that sparked our imaginations and rewards careful observation. Even better, by the climactic finale, we felt a real emotional connection with the characters. If you're a fan of games that take you to new and interesting places, Cradle is absolutely worth the ride. ■





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It's not often you hear terms like "roguelike," "permadeath," and "procedurally generated" in the same description as "abstract poetry," "nonviolent," and "relaxing." But that's the best way to describe the unique indie game *Rymdresa* (Swedish for space trip) from the development duo Vendela Carlberg Larsson and Kim Gunnarsson.

The game is a 2D space odyssey in which you explore a seemingly endless field of stars in one of a handful of spaceships. At the outset, the earth has been destroyed by an asteroid and your goal is to travel ever farther and wider to gather resources, gain experience points, and level-up your spaceship and pilot.

There are three chapters in *Rymdresa*, and each one gives you a different goal, such as to find a new home base, upgrade the home base, and upgrade your mothership. The game uses simple shapes for the spaceships, and the points of interest are trichromatic pixel art. Bursts of color come from passing through different regions, which feature starfields tinted shades of green, yellow, purple, orange, red, and white. As you explore, you'll find new engines that let you go faster, skins to change the look of your spaceship and sentry (read: waypoint indicator), and other upgrades that make traversing the stars faster and easier. There are also consumable objects that give you an instant boost of resources, send out reconnaissance drones, and warp you back home in the blink of an eye.

Your sole source of life—resources—are spent as fuel to maneuver your ship. When you run out, you die. But resources are everywhere, and the further you explore, the more you'll encounter. Later in the game you need materials to upgrade your mothership and home base, which can also be found by exploring the cosmos. You accrue a currency called Spacepoints

In Space, No One Can Hear You Rhyme

BY ANDREW LEIBMAN

\$11.99 (PC, Mac) • ESRB: Not Rated • Morgondag
rymdresa.com

for buying new ships. These you'll retain, along with items and upgrades, whenever you die. As roguelikes go, this one is on the more forgiving end of the spectrum.

There are jump gates that will take you far from the safety of home but offer a better chance at obtaining legendary objects and oodles of materials. The procedurally generated nature of the game makes it so that space truly feels infinite, but the encountered objects are frequently recycled. Before the third chapter, you've pretty much seen everything there is to see.

There are obstacles that must be avoided, and each heavenly body you scan carries the risk of sapping resources rather than granting them. As you progress through the chapters, you encounter more hostile objects, but they only engage you if you stumble blindly into them. The larger hostile objects, such as suns, will pull you in with their own gravitational fields, so give them a wide berth. This is a nonviolent game, remember, so your only recourse is to run away. In keeping with the pacifist theme, this game features a handful of very unusual boss battles.



As you spend more time in space, your pilot will level up, and each year's passing is marked with a short spoken poem. These interludes aren't very informative, and we wonder if some of the wordplay, meter, and patterns that we tend to expect from poetry haven't been lost in the translation. That said, they do a decent job of conveying the senses of loss, sadness, hope, and regret that seem to punctuate the game.

The music of *Rymdresa* is one of the game's highlights, and each ship has a different series of songs associated with it. This is a game built for multiple playthroughs, with dozens of poems, seemingly hundreds of items, and more waiting to discover and unlock. If you're looking for a roguelike with a more relaxed pace, this game was made for you. ■



Set in Victorian-era London, *The Swindle* takes the tried-and-true cops and robbers formula, mixes in the essentials of a great 2D platformer, adds a heaping amount of steampunk aesthetic, seasons the whole thing with a dash of *Spelunky*, and then serves it to you hot and fresh. It's a winning recipe, and we found ourselves coming back for extra helpings.

As the game begins, Scotland Yard is planning to up its law enforcement game with the introduction of The Devil's Basilisk, an all-seeing surveillance AI that will make your life of thievery impossible. The best way to stop The Devil's Basilisk? Steal it, naturally; you have 100 days to do so before it goes online.

First things first, though. You can't pull off a heist of that magnitude right out of the gate, so, in RPG fashion, you have to go about buying and upgrading gear for your crack team of catburglars so that they're capable of foiling later levels' advanced security systems. You will, of course, be stealing the cash necessary to finance these purchases.

Your crime spree begins where security is lightest: the various hovels of *The Swindle*'s slums. Levels are procedurally generated, meaning you'll never get the same one twice. However, the game's various security measures—robotic guards, traps, and so forth—are each bound by their own set of capabilities (and weaknesses), so you can methodically plan each caper even though you've never seen a given level.

The double-edged sword of games that rely on randomly generated levels has never been sharper than it is in *The Swindle*. Because every building's layout is different, you have to think your way through each and every level, as opposed to committing enemy patrol routes and trap locations to memory. It's refreshing and challenging at the same time. On the other hand, you can find yourself with a building layout that's impossible to defeat. If the game's RNG locates the bulk of a property's riches behind a wall and you haven't purchased bombs, well, tough crumpets, old chap.

Determining the best way to outmaneuver *The Swindle*'s assorted obstacles requires a fair deal of trial and error. That means dying, early and often. Whenever one of your plucky bandits does

Steampunk Burglary For Fun & Profit

BY VINCE COGLEY

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eat it, they're gone for good, in roguelike fashion, and the next thief up takes his or her place. Cash multipliers a particular Swindler earns for pulling off successful heists perish with him or her, so to a certain extent your thieves are more than meat you can haphazardly throw into a steam-powered grinder. Purchased gear and upgrades do persist beyond death, mercifully.

Aside from the gameplay itself, which is thoroughly addictive if slightly annoying at times (see below), one of the most compelling aspects of *The Swindle* is its psychology. In a lot of instances, you become your own worst enemy, as *The Swindle* tempts you to pilfer every last dollar from a level, even if doing so means certain death. And when you do trip an alarm or wind up spotted by a guard, the music intensifies and the level's sentries' searchlights change to red. Whenever this happened to us, our pulse quickened and our nerves frayed, which is solid evidence that *The Swindle* is doing it right.

Other critics have noted that *The Swindle*'s controls aren't as tight as they need to be for a platformer that brutally punishes your every mistake, and that criticism isn't entirely unwarranted. Ultimately, it wasn't a deal breaker for us. Our own greed and/or stupidity got us killed far more often than any unfortunate snag in the game's controls.

Despite a few shortcomings, *The Swindle* left us itching to play "just one more heist." Thanks to a playfully charming world, devilishly fun arsenal of gadgetry, and an unforgiving level of difficulty, this steampunk platformer will steal your heart and rob you of your free time. ■



Q&A With Buddy Bland

The Push For High-Performance Computing & Exascale Systems

In late July, President Barack Obama issued an executive order authorizing the establishment of the NSCI (National Strategic Computing Initiative). The NSCI focuses on HPC (high-performance computing) at the federal level and will see multiple federal agencies coordinating efforts to research, develop, and deploy an exascale computing system reaching 1 exaflop calculations per second. For comparison, an exaflop is about 1,000 petaflops; today's top supercomputer, China's Tianhe-2, hits 33.86 petaflops, and the U.S. Department of Energy's Oak Ridge National Laboratory Titan system rates second at 17.59 petaflops. We spoke to Buddy Bland about NSCI, HPC, and exascale-level computing. Bland is the project director for the DoE's Oak Ridge Leadership Computing Facility, home to Titan and the upcoming Summit supercomputer that will supplant Titan performance-wise. (For our full interview, go to www.computerpoweruser.com/18055.)

Q: What does your work at the Oak Ridge Leadership Computing Facility involve?

BB: I'm the project director for the Department of Energy's Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory. My job is to acquire new machines and make sure they meet the requirements of our users. And we have a vast user community both in this country and around the world: the scientific user community needing high-performance computing. So I'm responsible for bringing in the new machines, and then I have operational responsibilities once they get here, making sure those machines actually run and perform well and do the science that's needed by our users.

You have world-renown scientists who are clamoring to get access to our machines to be able to do their research. So we get to interact with some of the smartest people in the world and help them solve some of the most difficult problems in the world. And these are problems that impact everybody's ability to live. Everything from climate modeling and understanding what's causing climate change and what can we possibly do about it to creating new energy-storage techniques such as ultra-capacitors to be able to store energy when a car stops or store the energy from a braking system so that it can go back into an electric motor and make the car go again rather than just



turning all that energy into heat, to creating 500-mile batteries so that in an electric car you basically charge it once a week and you're able to go 500 miles in it, to basic science problems like why do stars explode or how do you create new nano materials that have certain properties? All of these things are tremendously important to the United States and the world in general. High-performance computing is one of the few things in the world where you can have an impact in all of these areas, not just in one science area.

Q: What is your perspective on the NSCI? Is such an initiative and a

stronger emphasis on HPC and exascale-level computing needed?

BB: Absolutely. Among scientists, there's an insatiable appetite for HPC. I've been in this business for 35 years, and it continues to grow and be more and more necessary as we look at the big problems that are going on in the world such as climate change, energy technology, and renewable energy. All these things are enormous challenges for the scientific community, and most of these you can't make a lot of progress without modeling and simulation. You can do some, but modeling and simulation has really become kind of the third leg of science along with experimental and theory. So HPC computing and modeling and simulation are absolutely required.

Now why do we need an NSCI? Well, over the past 30 years, we've seen computers get faster and faster, but for a long time (up to the early 2000s), we were seeing the performance going up by just the clock rate on processors getting faster. Since about 2003 or 2004, the clock rates of processors have not gotten any faster. We've gotten some performance improvements from the architectural changes inside the chips, but not nearly enough to get Moore's Law rate of increase of performance in the computers. So since about the 2003 or 2004, the big advances in the

performance of these supercomputers has come through parallelism.

When I started here in 1985, we had a single-processor Cray computer with one thread of execution. When we put our first big parallel machine here in 1995 (10 years later), it had 3,000 processors. When we put our machine here in 2005, another 10 years later, I'm going to say it had about 20,000 threads of execution, 20,000 processors. Today, our machine has more than half a million threads of execution, and the next machine we're going to get is going to have tens of millions of threads of execution. So parallelism has become the way of increasing the performance of applications.

As we start looking at our machines and trying to figure out what we're going to need to get to the exaflop computers in the next decade, we're going to be talking about tens of billions of threads of execution. So it's about understanding how to manage all of that parallelism and understanding how to make these computers run in a power envelope we can afford. Today our machine Titan peaks out at about 9 megawatts of power. That's as much as a small town, and it uses as much cooling water as the water company for a small town. So if we just continue to scale up the way we're doing, we would have a machine that uses as much power as a nuclear reactor in 2023, and that's just not tenable. Nobody can do that. We can't afford it and we don't want to do that. So we have to solve the energy problem.

We have to figure out how to make these computers run faster using less energy. We have to solve very complex cooling problems so we don't have to put so much energy into the cooling, and we have to solve the problem of how to manage all that parallelism, both from an application standpoint and from a system standpoint, hardware and software. How do you make it stay up and be reliable when you have literally hundreds of thousands of processors? Just the mean time to failure on a single component in a system gets you to where your mean time to interrupt on a computer of that size gets down to be measured in minutes or hours. And we need machines that will

Today our machine Titan peaks out at about 9 megawatts of power. That's as much as a small town.

stay up for days or weeks. So you have to solve those research problems.

It really does take a concerted effort. The key point here is companies such as IBM, Intel, AMD, HP, and Dell and the companies out there that build computers and processors, they're going to build machines that meet the needs of the commercial marketplace. And the commercial marketplace doesn't need 10 billion threads of execution that all stay up all the time. This is something that we need in the HPC space. So if we expect to have computers of that size, then the federal government needs to support R&D efforts that go into developing machines of that kind of scale. In a nutshell, that's why it's so important to have the NSCI—to help further the development of the machines, the system software, and the applications that use them all to be able to expand to these tens of billions of ways of parallelism.

Q : Beyond the numbers, what does exascale-level computing mean to you?

BB : First of all, "exascale computing" is a great buzzword, but it's a point on a continuum. When I first started this, our first Cray computer was about 150 megaflops. And then we got to gigaflops. And about 2000, we got to a teraflop. We got to a petaflop in 2008. Now we're looking at how do we get around a petaflop to get to an exaflop? Once we get to an exaflop, we'll be going on to the next thing—the zetaflop and beyond that. Exascale is not an end goal. It's a point on a continuum of the need for ever-increasing performance in high-performance computing.

That's the first way I look at it, but probably more to your question are the types of problems you can solve with this. So if we're looking at climate change, for example, with our gigaflop-level computers we were able to simulate the climate of Earth at a very high resolution, the kind of resolution you need to be able to look at the impacts to regions on the planet. We were able to spend about three weeks running on the computer to generate about an hour's worth of modeled time on the machine. So clearly, that's not something that's sustainable, where it takes three or four weeks to model one hour's worth of simulated time.

When we go to the teraflops-level of machine, in one day on the computer we could simulate five days of model time. Now, that's starting to get to the point where it's close enough to being interesting to the scientist that they can actually do that. Now that we're at petaflops, we can simulate not only multiple days of simulated time in a single day—probably 50 days of time in one day on the machine—but we're doing it at a much higher resolution and we're adding much more physics and chemistry. We can understand the impact of clouds. Those early models didn't take clouds into account at all, didn't take atmospheric chemistry into account at all.

Being able to add all this fidelity to the model means we get answers that we believe much more. It also allows us to run multiple simulations in what we call ensembles and then look at the averages over many different models and many different simulations so that we understand the error bars, the bounds of what we think is reality out of these simulations. So it gives the decision makers in the

government a lot more information about what can happen and is likely to happen.

But you don't have to be a giant company or big government lab to be able to use one of these computers. We had a very small truck company that was trying to solve a problem. California had imposed a new fuel economy standard for 18-wheel trucks, which needed become about 10% more fuel efficient than what they were before. This company came to us. We get a code from NASA that can do computational fluid

is somewhere near 150 petaflops, but more importantly than the raw peak number is that our contract with IBM calls for this machine to run applications at least five times faster than they're able to run on our current machine, Titan. So it will have three times more memory than Titan. One really interesting thing we're putting in is that each node will have some flash memory, some non-volatile memory to be able to store data long-term to minimize the amount of data that we actually have to write out to the file

power over a year costs more than \$1 million. So that's over \$100 million a year just to plug the machine in. That doesn't even count all the work of actually doing work on the machine. So that doesn't make sense. We have to solve this power problem and make the machines more powerful in the future and do that much more energy efficiently than they're doing it today.

There are interesting technologies. Your cell phones have exactly that same type of driver. You want your battery life to be as long as possible, so you want the processors in the cell phones to be very energy-efficient. So that's an area where the business side of the vendors and the HPC side align very well. We both want more power-efficient processors to be able to do the work. But there are other areas that are challenges, and they don't necessarily align with the business strategies of the various vendors. We have machines that will use 10 billion threads of execution. Today, Titan has about 500,000 threads of execution. Being able to manage all that parallelism is just an incredibly complex problem. Being able to get the applications to scale up and use 10 billion simultaneous threads of execution and to be able to keep all that running at the same time is an enormously difficult problem and one that the vendors have no commercial need to address because nobody else does this. This is something you need NSCI to help address because it won't get done if someone doesn't go in and drive that work. So the government is stepping in to help and drive that work.

Then the third area is the resilience. When you have 10 billion threads of execution and hundreds of thousands of processors and millions and millions of DIMMs in a machine, how do you keep all that stuff running? You know that certain things are going to be failing, so how do you manage the failures so the applications can keep running? This is a problem that needs the NSCI to step in and help solve, otherwise it doesn't get solved and we don't end up with the machines we need to be able to address the nation's most burning problems and competitiveness issues for U.S. industries. ■

You don't have to be
a giant company or big
government lab to be able to
use one of these computers.

dynamics to model the airflow around the truck. We get our big supercomputer and work with them for the model of the truck, and in 18 months from the time they came to us, they had a product in the field where they had done modeling and simulation and designed air foils that would go on these trucks to make them 10% more fuel-efficient. These are the kind of changes we make to society that have a huge impact. If every truck in the nation could get better fuel efficiency, what would that mean? How many fewer oil tankers would be coming from the Middle East? It's a huge impact.

Q : What does the Summit project entail?

BB : Summit is our next computer that will replace Titan. It will be delivered starting in 2017 and go into production for our users in 2018. It's a machine we're buying from IBM. It will have IBM Power9 processors, as well as NVIDIA Volta GPUs. It will use Mellanox high-bandwidth InfiniBand interconnect to link all the nodes together. The basic performance we expect

system. The capacity of the file system will be about 120 petabytes and will be able to transfer data at about 1 terabyte a second. So this is a big system by anybody's standards. It will be about the size of a basketball court and use about the same amount of power as Titan, maybe 10% more, so it will be in the 10 megawatts range of power. It will use enough cooling water for a small town.

Q : What are some notable obstacles that stand in the way to reaching exascale computing?

BB : There are several important hurdles, including power and cooling. You have to figure out how to solve the problem of power. If we just took Titan today and scaled it up to an exascale machine over that time period and just expected kind of Moore's Law changes in the performance of chips and so forth, we'd end up with a machine that used somewhere in the neighborhood of 100 megawatts in power. That's as much as a pretty good-sized town. A town of 35,000 to 40,000 people uses 100 megawatts of power. A megawatt of

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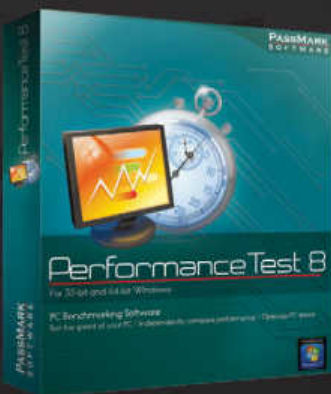
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Q&A With Eric Kuo

MSI's VP of Global Sales & Marketing Talks MGA & PAX

Q: What is MSI MGA, and how did it come about?

EK: MSI MGA, also known as the MSI Masters Gaming Arena, is the successor to the long-running MSI Beat IT event that we have organized for the past few years, and it is the sixth event since 2010. Starting early this year in January, the team started planning to make a very impressive event for fans and partners to enjoy. We started exploring possible collaborations with the top companies in the eSports industry, which led us to this opportunity to work closely with ESL and Blizzard Entertainment.

Q: What games are included in MGA competition for individuals and/or teams?

EK: For the top-quality games in the individual category, we will be continuing last year's tradition to organize a StarCraft II event, although for this year, it will be an official WCS Global Event, making it one of the most highly anticipated events for professional StarCraft II players to attend. As for the team category, we will also be organizing the first international Heroes of the Storm tournament with the highest prize pool outside of BlizzCon, featuring top teams from all over the world.

Q: What kinds of prizes are up for grabs in MGA competition?

EK: At the MSI Masters Gaming Arena event, \$75,000 USD in



cash is up for grabs, and because it's a StarCraft II WCS Global Event, there are also WCS points awarded to players who qualify and win. A total of \$25,000 USD is distributed among 16 players based on their rankings, while \$50,000 USD is distributed among the top three teams that compete at this event.

Q: How do teams or individual players get involved with MGA to begin with? Is there a sign-up process or

elimination tournaments, or is MGA an invitational tourney?

EK: We started MGA in June with separate regional qualifiers for the U.S., Europe, and Asia, and over the course of two months, teams around the world competed to reach the grand finals. We worked very closely with ESL, utilizing its platform and infrastructure to create a competitive and fair playing field.

Q: It looks like the MGA finals took place at PAX Prime in Seattle in late August, is that correct? How many and what events led up to the finals?

EK: MSI Masters Gaming Arena featured its Global Grand Finals at PAX Prime this August, from the 28th to the 31st of August. There were five regional qualifiers held for Heroes of the Storm, with seven qualified teams and one direct invite, as well as 10 qualified players and six direct invites for the six regional qualifiers for StarCraft II.

Q: How has the response been to the MGA, both from a contestant/team standpoint and from the standpoint of attendees and audience members at the events?

EK: As the qualifiers are conducted online via the ESL platform, players have responded extremely well to the opportunity of playing in such a tournament, noting that it is also the first international Heroes of the Storm tournament. With some of the best StarCraft II and Heroes of the Storm teams from around the globe attending, I am sure that everyone is just as excited as I am to see the conclusion of the Masters Gaming Arena.

Q: Can people who are unable to attend an event in person still catch MGA competition in real time via streaming, and if so, how does this work?

EK: People are able to catch the MSI Masters Gaming Arena event online via Twitch.TV at our MSI channel here: twitch.tv/msigamingameu.

Visit us at gaming.msi.com/mga for more details on MGA.

Q: Speaking of PAX Prime, it looks like you had something called the eSports Experience at your booth at the show. Can you tell readers more about this?

EK: We love watching eSports at MSI, but we love playing more. We want all the gamers out there to feel what it's like to play on a professional eSports stage. At events just like PAX Prime, we bring a premier eSports stage for attendees to compete on, a huge LED wall for viewers to spectate, and famous Twitch streamers to cast the games, and we live-stream it online for the world to see.

Q: It seems like eSports events have really grown by leaps and bounds the past few years. What other types of eSports involvement does MSI have in the eSports arena, and where do you think eSports are headed in the future?

EK: We work with multiple organizations such as CEVO and MLG to really help drive eSports into the mainstream by creating platforms, content, and communities for gamers to enjoy. Even with the explosion of growth in the past few years, I think that there are so many things that haven't been done in the realm of eSports. We will definitely see an evolution in the industry, and people around the world will be competing in exciting ways.

Q: Does MSI have a similar MGA schedule planned for 2016, or is it too soon to talk about that yet?

EK: Currently, we are a bit too far away to talk about what we're planning for 2016, but every year we definitely are trying to raise the bar. We want gamers around the world to be able to compete with the very best at amazing venues and locations. Masters Gaming Arena 2016 will definitely be something to look forward to. ■



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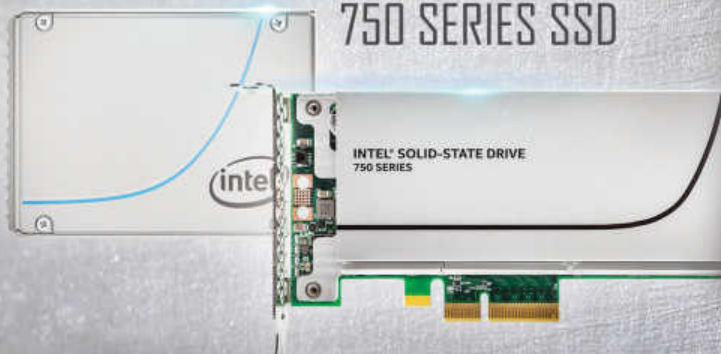
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